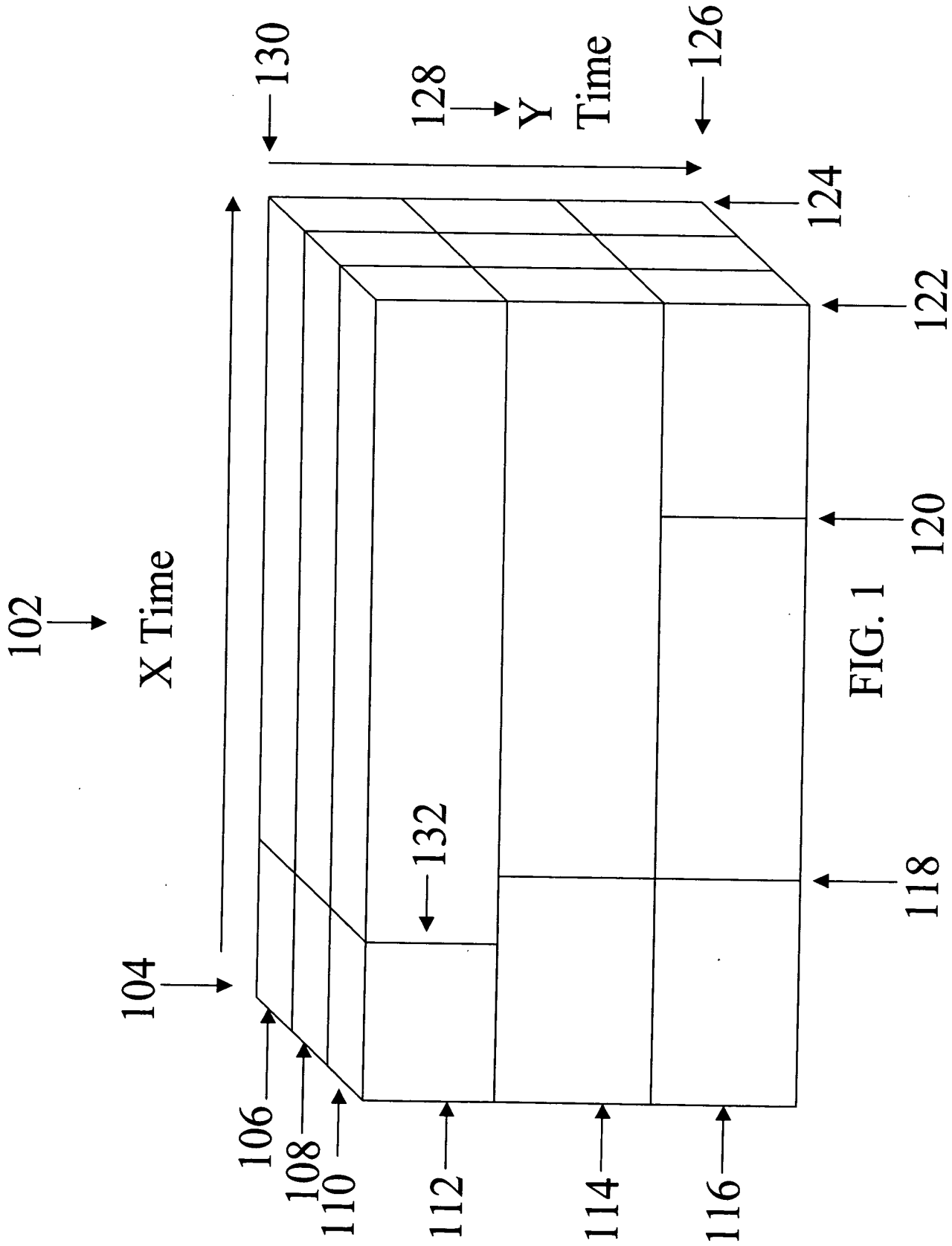

102
X Time
104
106
108
110
112
114
116
118
120
122
124
126
Time
Y
128
130
132

FIG. 1

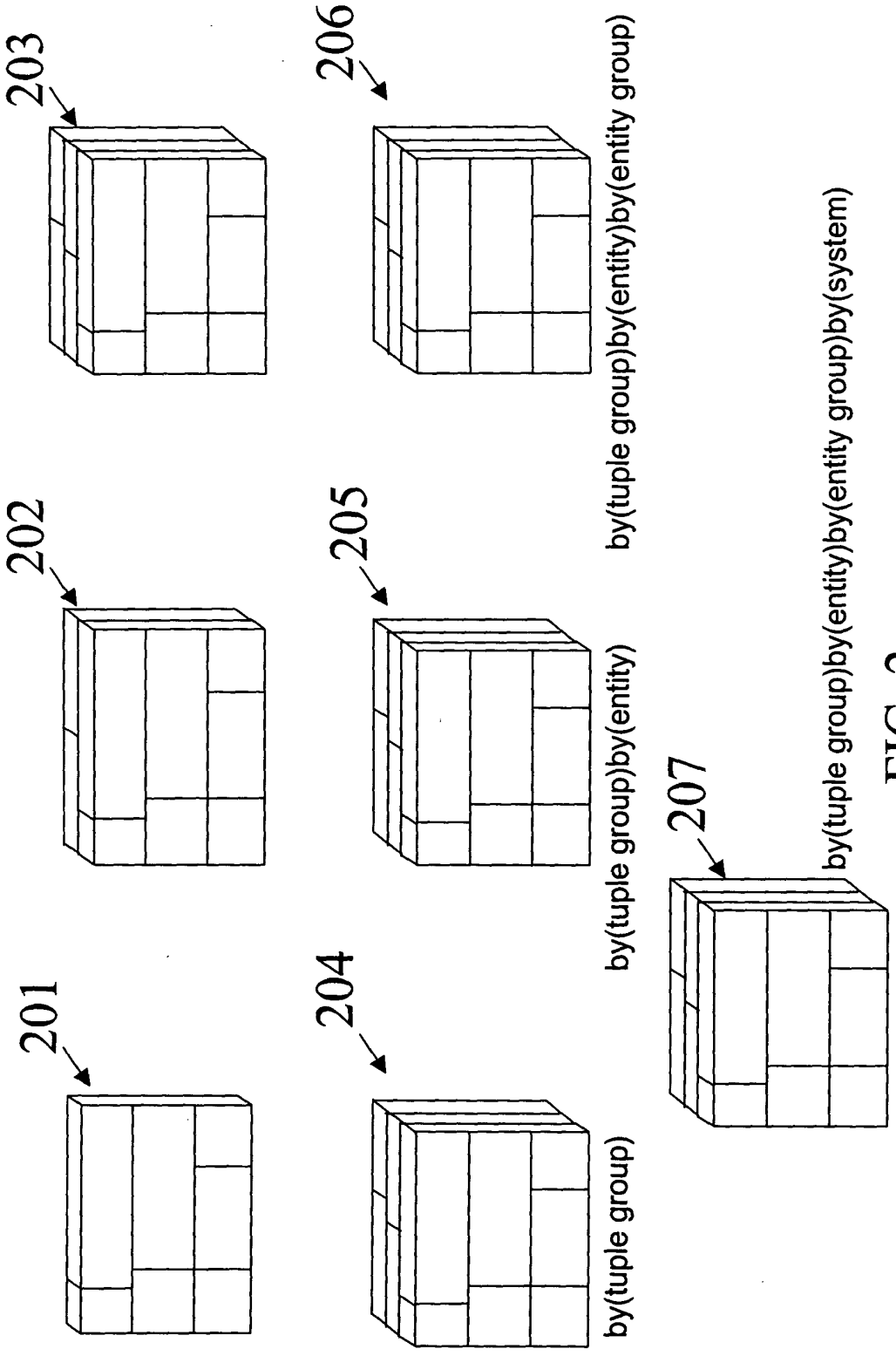

201
by(tuple group)
202
by(tuple group)by(entity)
203
204
by(tuple group)by(entity)by(entity group)
205
by(tuple group)by(entity)by(entity group)by(system)
206
207

FIG. 2

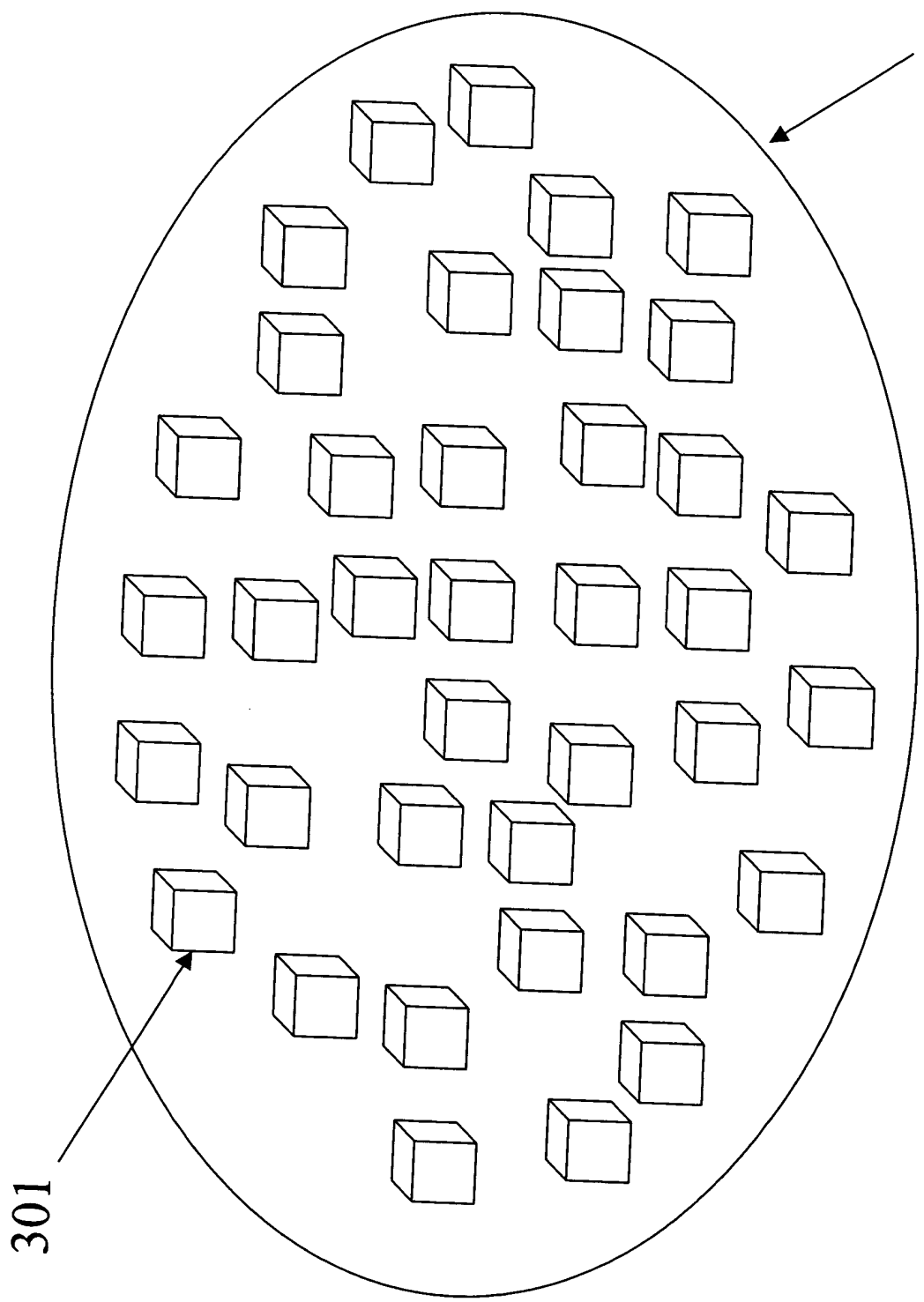


FIG. 3

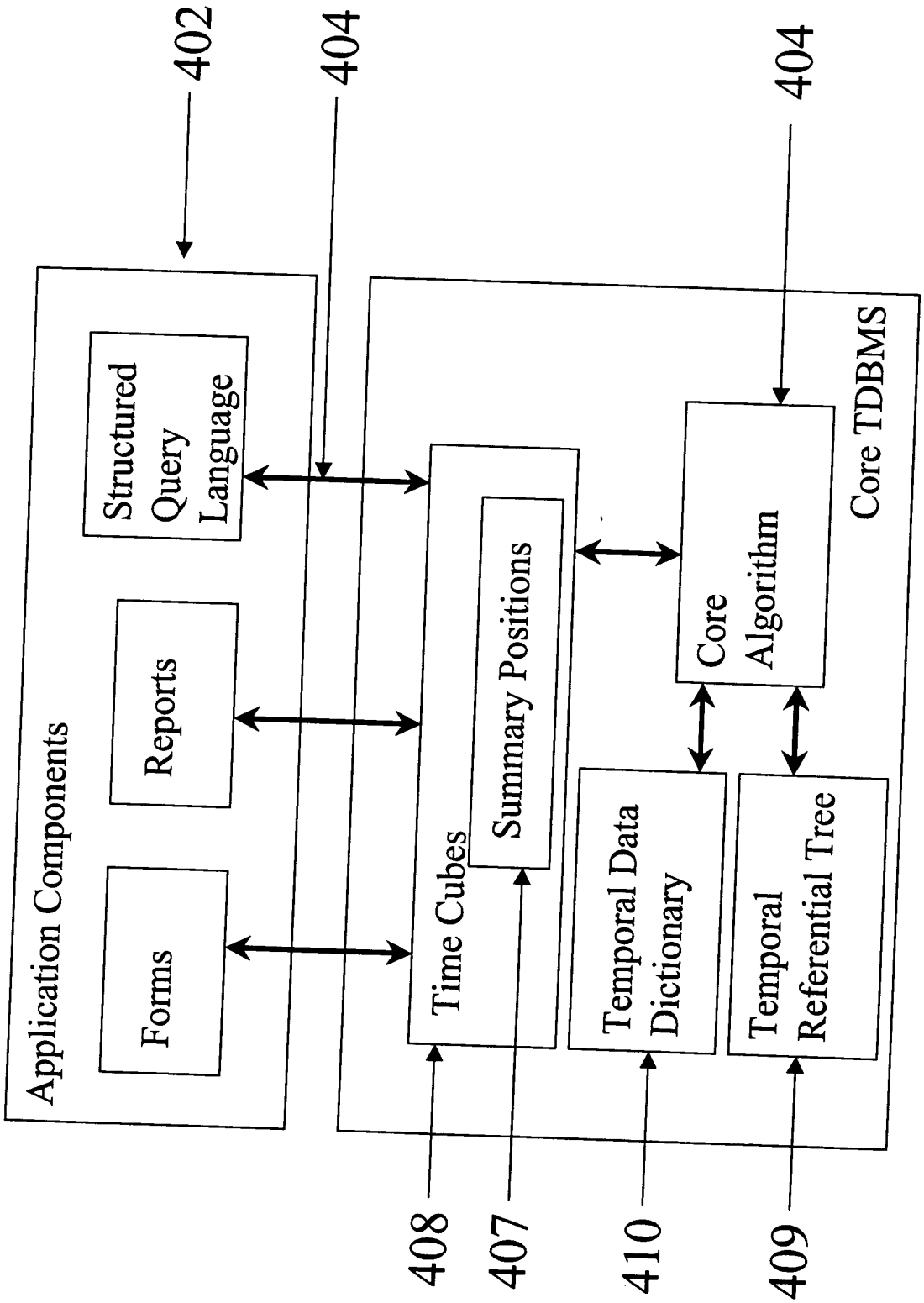

402
404
404
Application Components
Forms
Reports
Structured Query Language
Core TDBMS
Time Cubes
Summary Positions
Temporal Data Dictionary
Temporal Referential Tree
Core Algorithm
408
407
410
409

FIG. 4

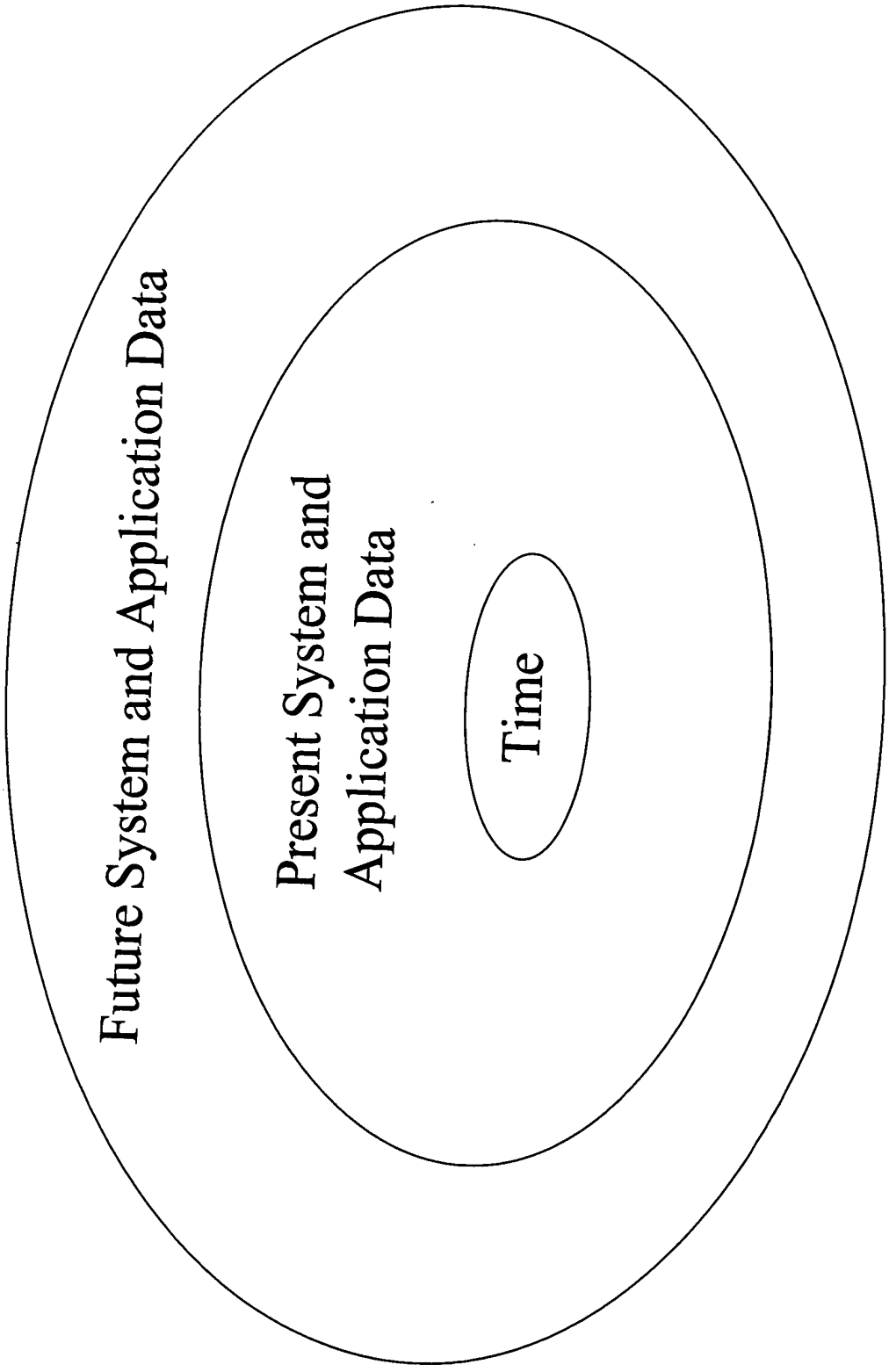

Future System and Application Data
Present System and Application Data
Time

FIG. 5

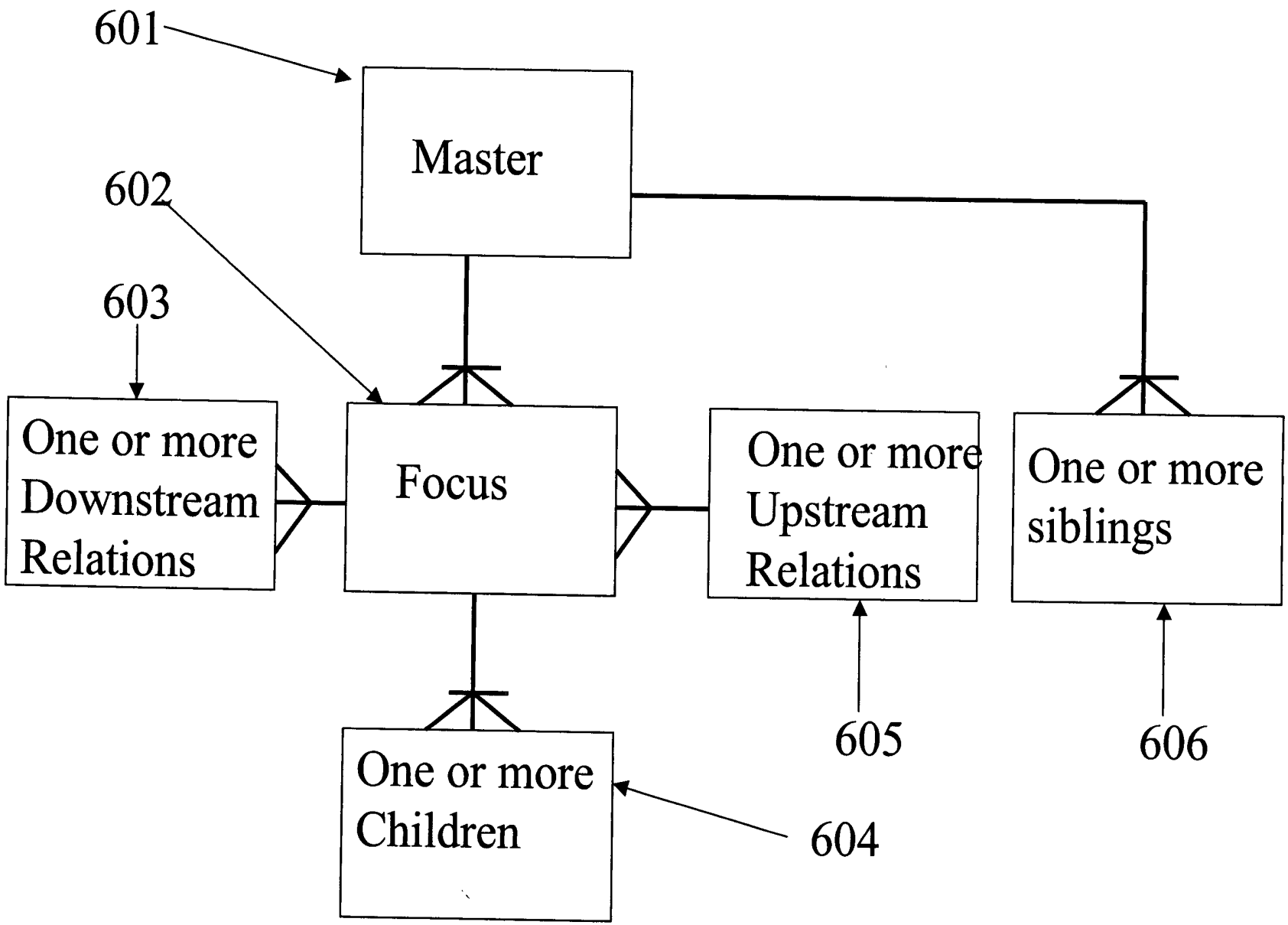

601
Master
602
603
One or more Downstream Relations
Focus
One or more Upstream Relations
One or more siblings
605
606
One or more Children
604

FIG. 6

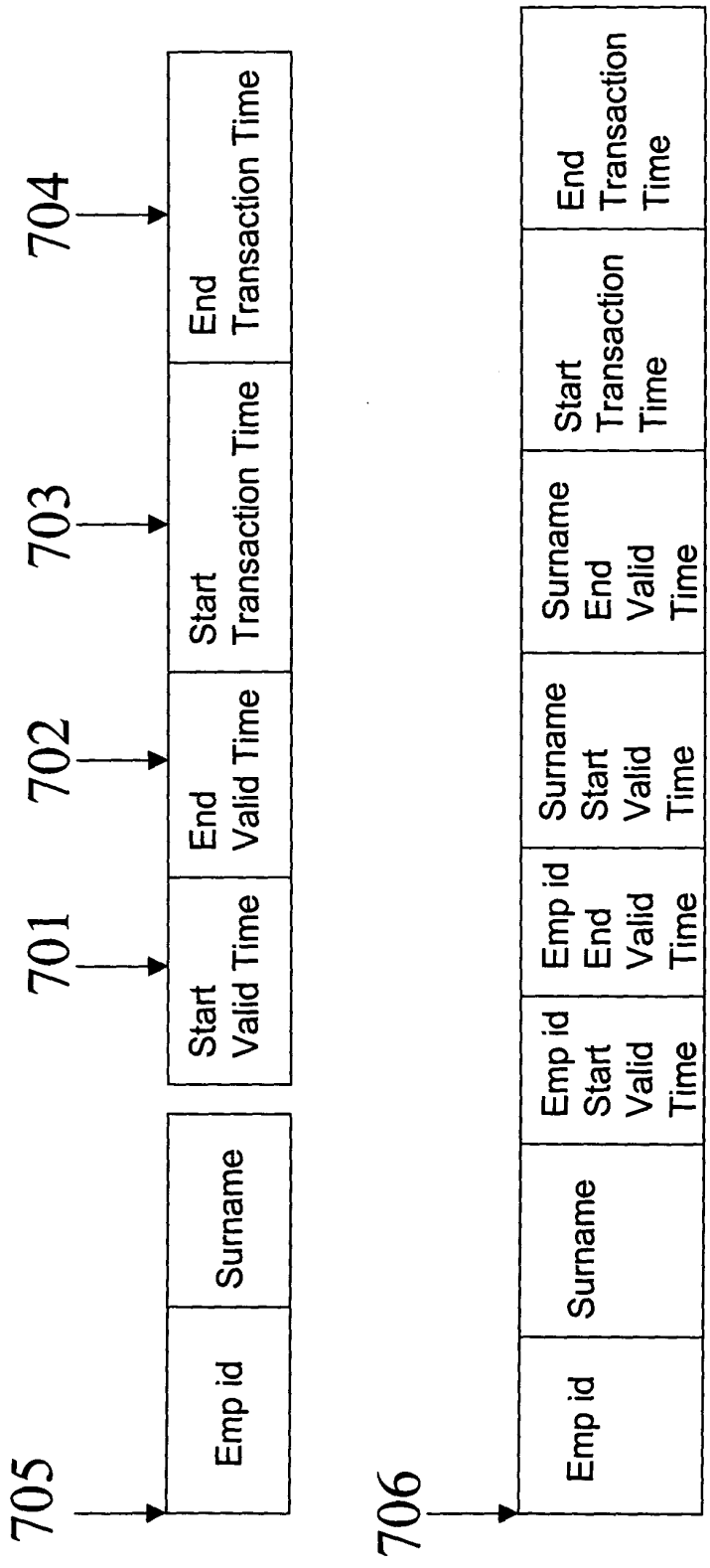

705
Emp id
Surname
701
Start Valid Time
End Valid Time
702
Start Transaction Time
703
End Transaction Time
704
706
Emp id
Surname
Emp id Start Valid Time
Emp id End Valid Time
Surname Start Valid Time
Surname End Valid Time
Start Transaction Time
End Transaction Time

FIG. 7a

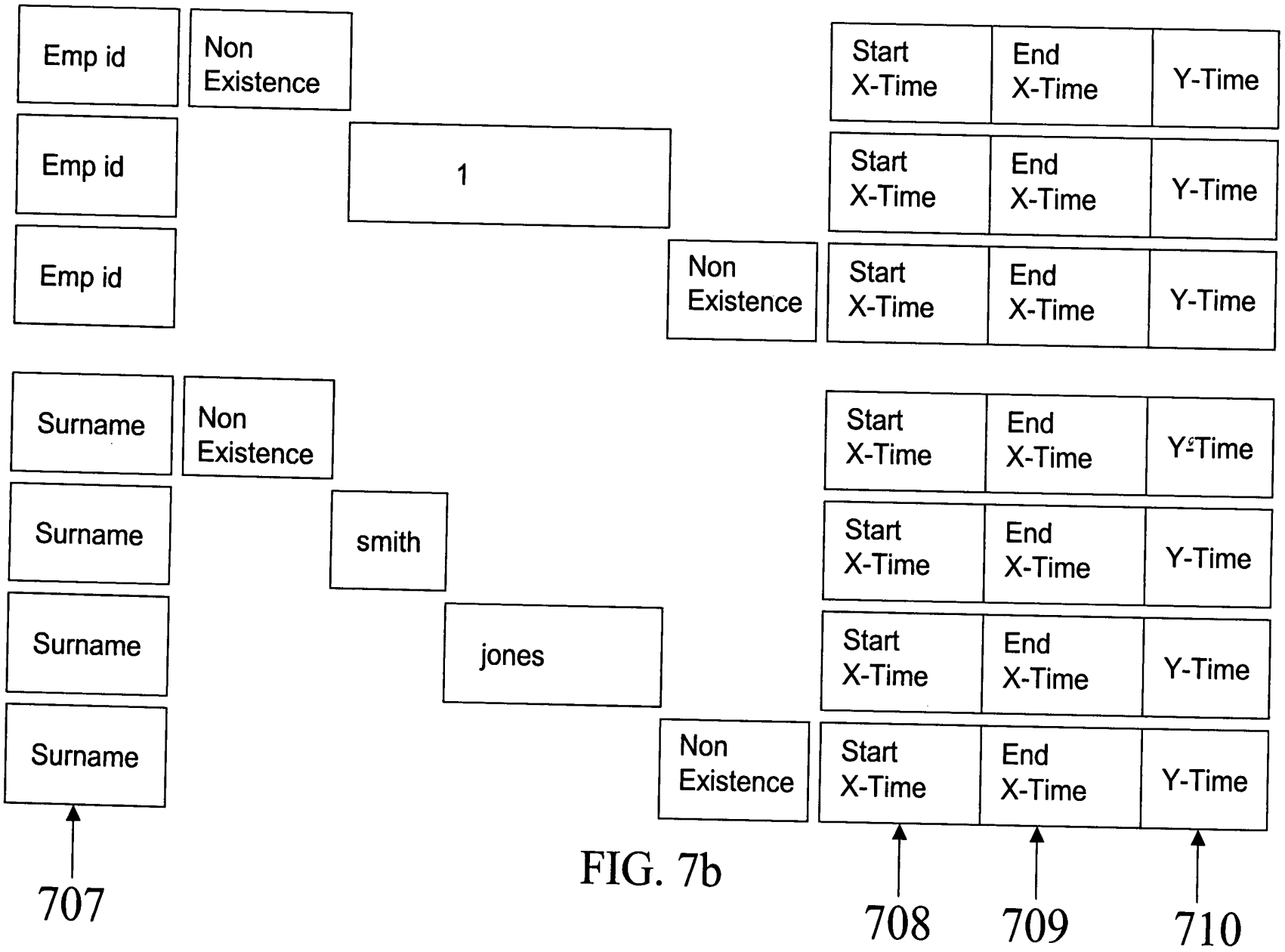

Emp id
Non Existence
Emp id
1
Emp id
Non Existence
Surname
Non Existence
Surname
smith
Surname
jones
Surname
Non Existence
Start X-Time
End X-Time
Y-Time
707
708
709
710

FIG. 7b

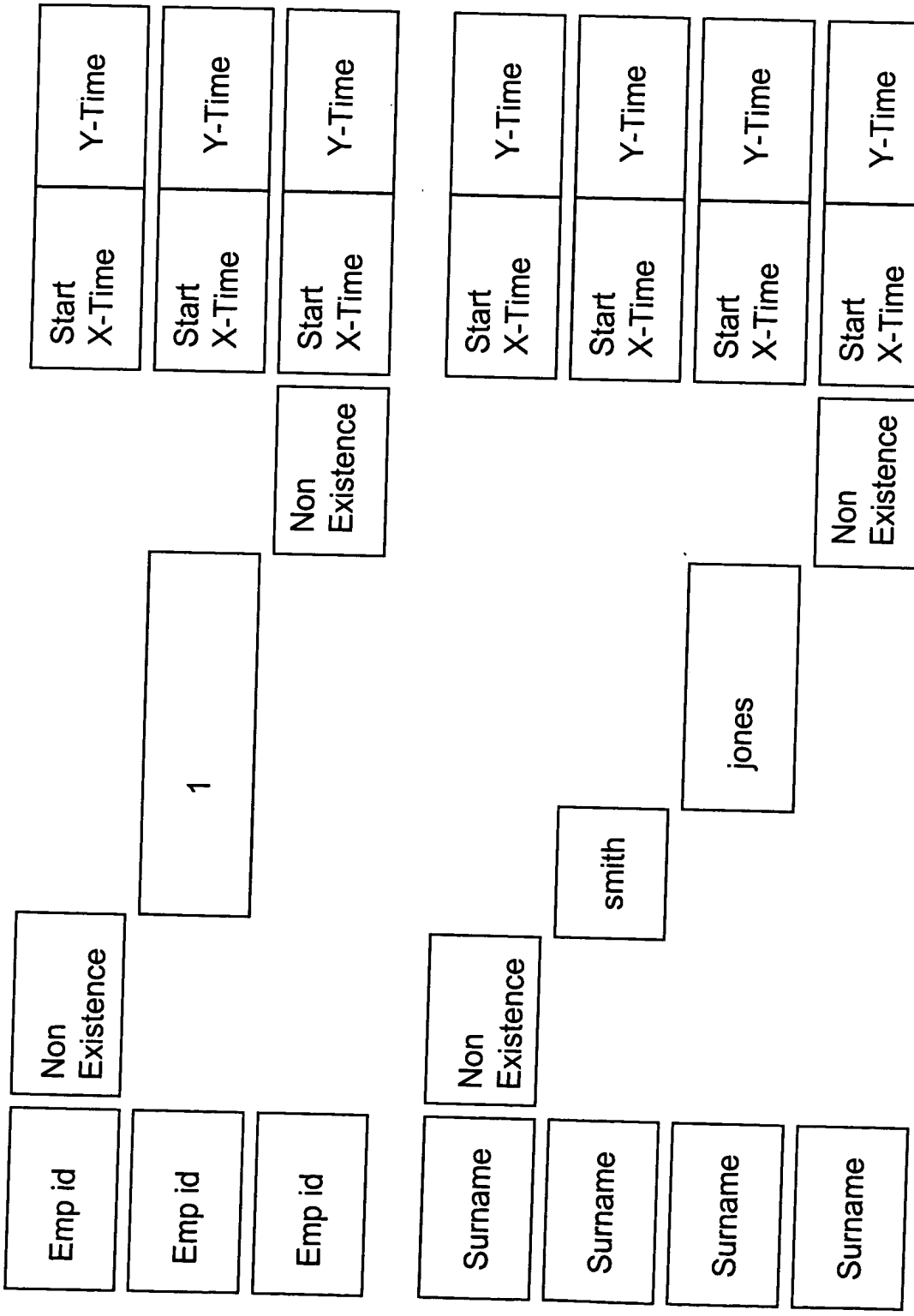

Emp id
Non Existence
Start X-Time
Y-Time
Surname
Non Existence
Start X-Time
Y-Time
Emp id
1
Start X-Time
Y-Time
Surname
smith
Start X-Time
Y-Time
Emp id
Non Existence
Start X-Time
Y-Time
Surname
jones
Start X-Time
Y-Time
Surname
Non Existence
Start X-Time
Y-Time
711
712

FIG. 7c

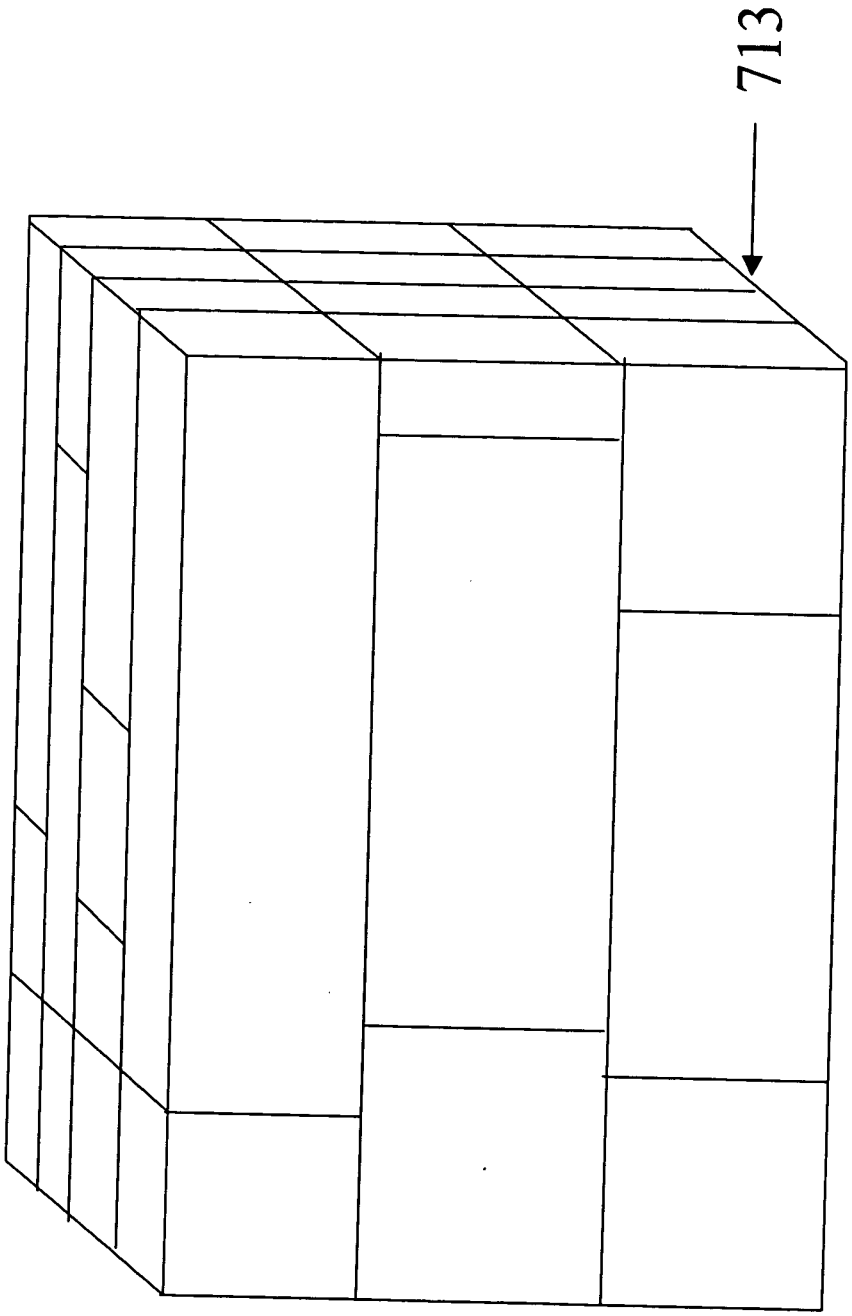


FIG. 7d

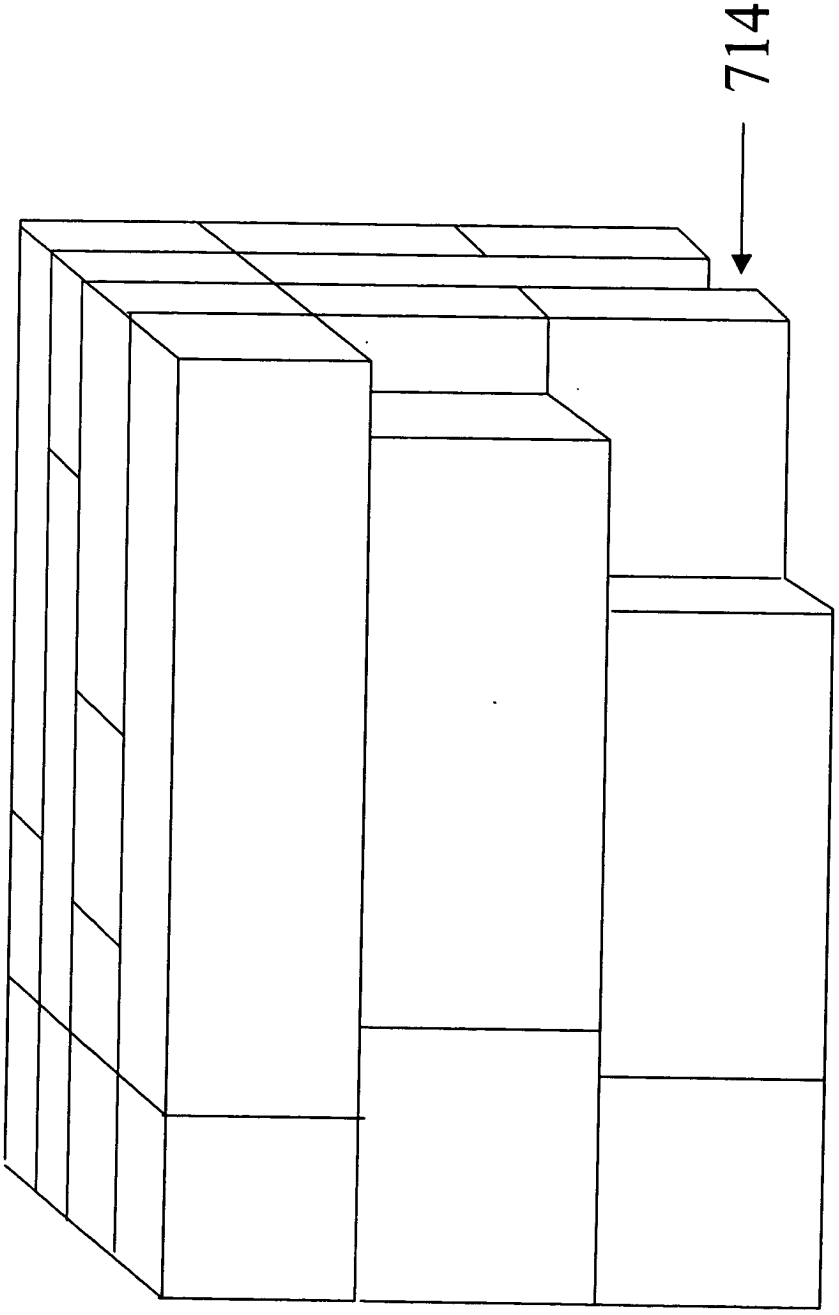


FIG. 7e

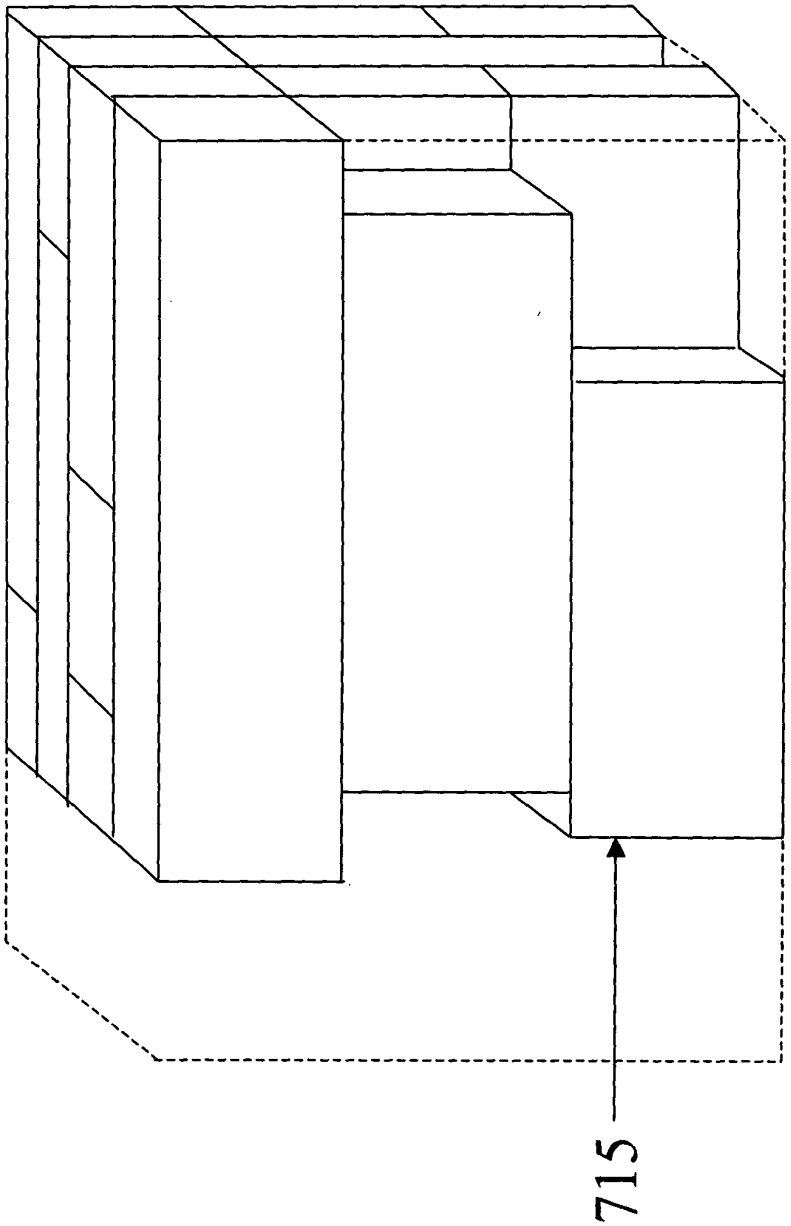


FIG. 7f

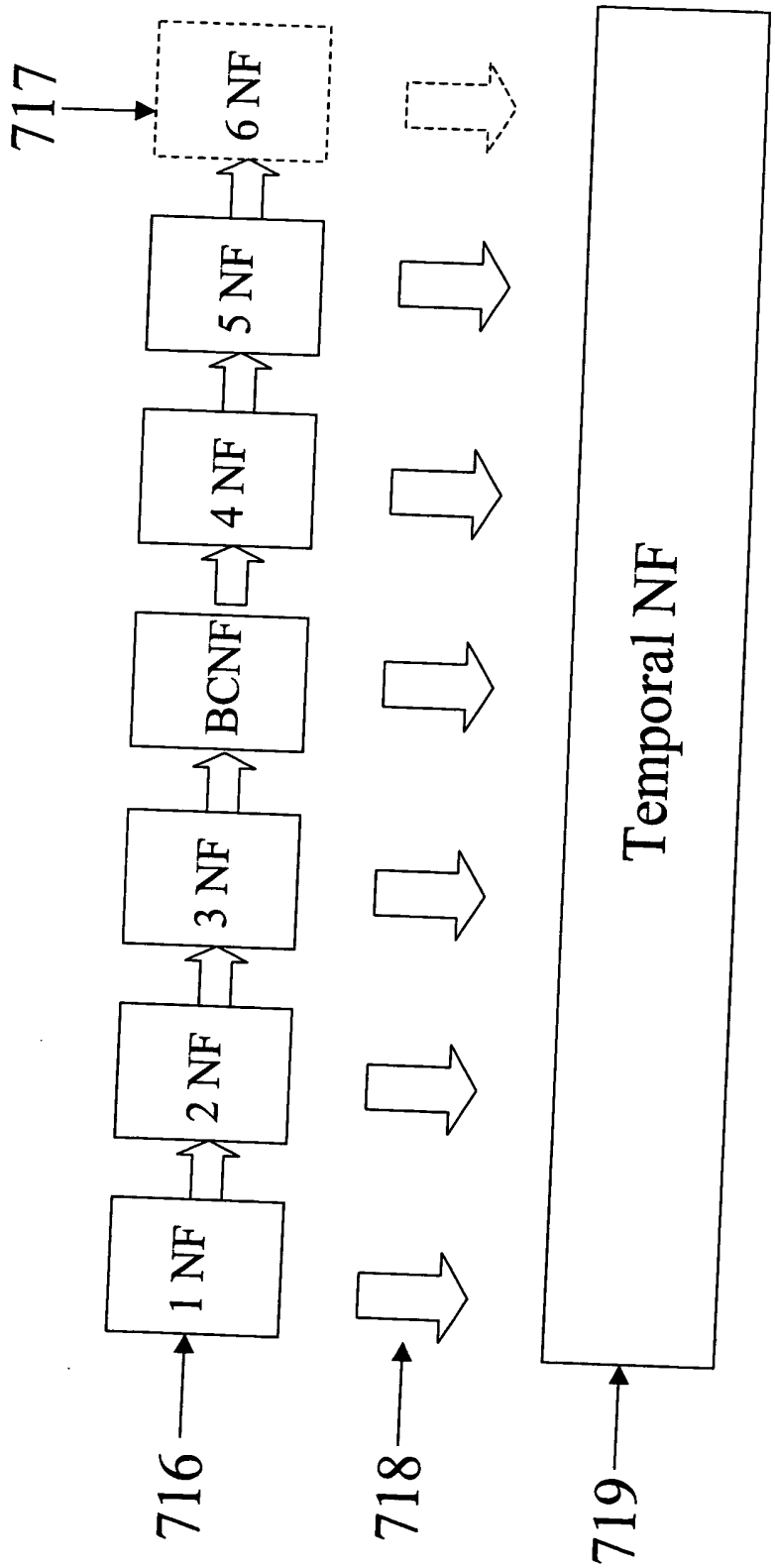


FIG. 7g

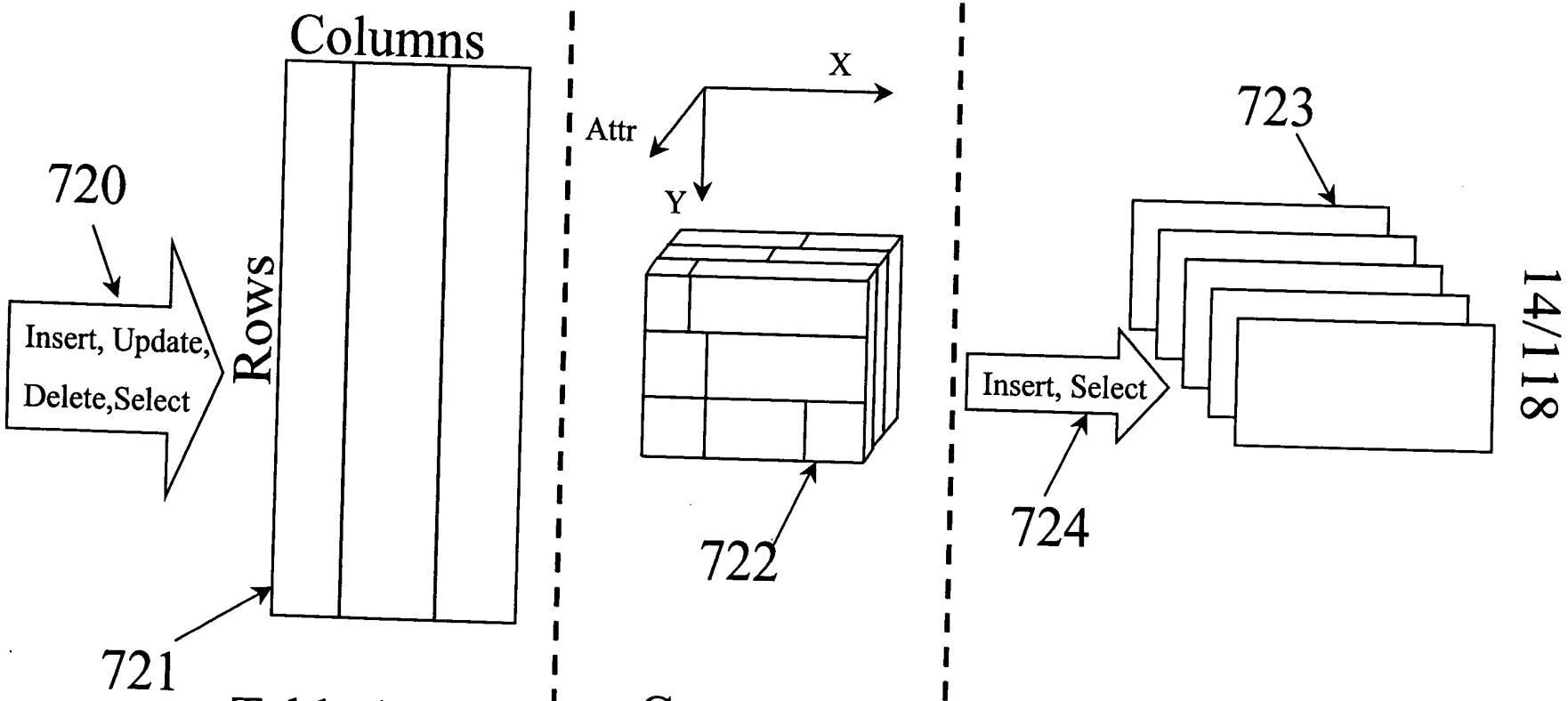

Columns
Rows
720
Insert, Update,
Delete,Select
721
Table / View
X
Attr
Y
722
Conceptual
Time Cube
723
Insert, Select
724
Physical Data
Model

FIG. 7h

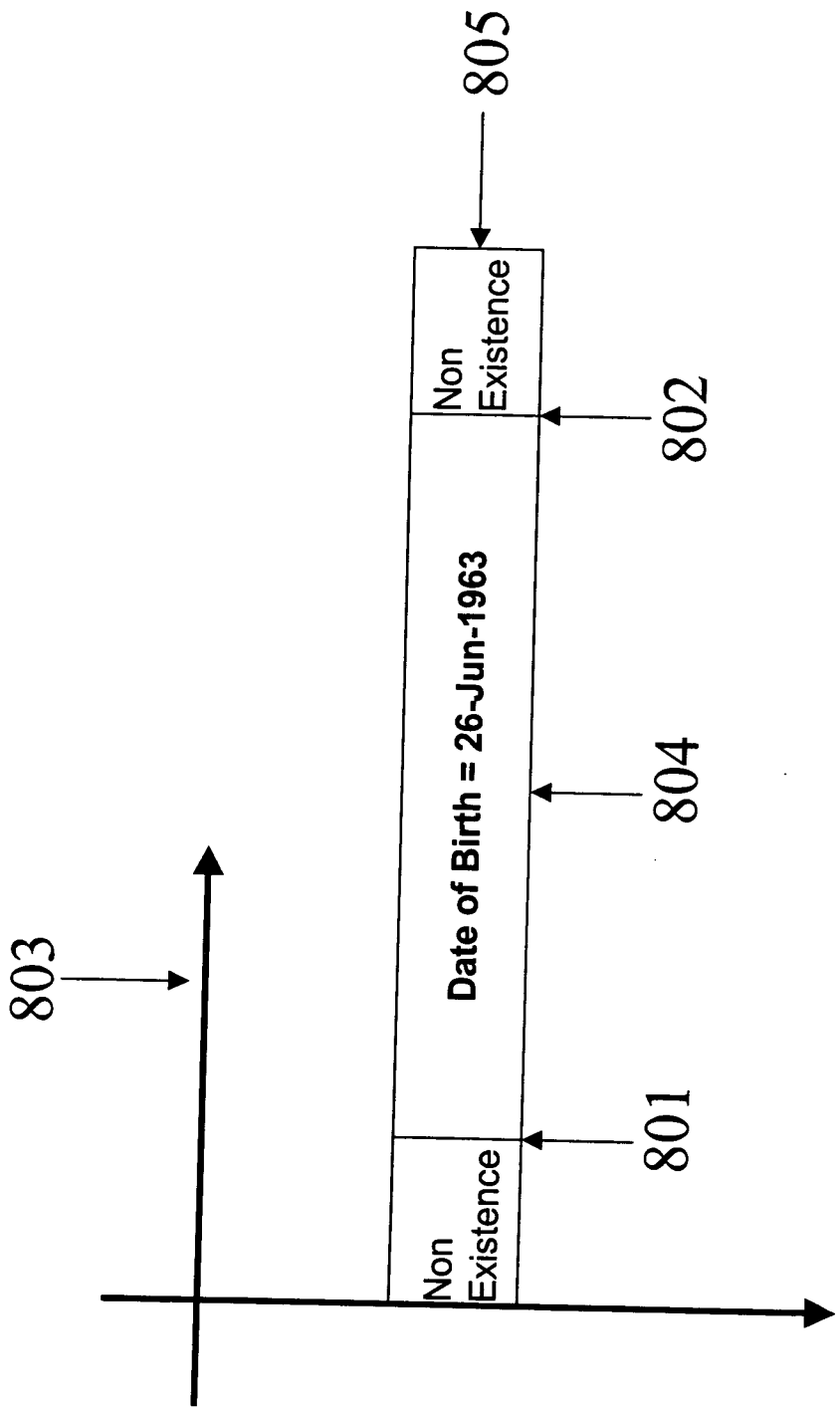

805
Non Existence
802
Date of Birth = 26-Jun-1963
804
803
801
Non Existence

FIG. 8

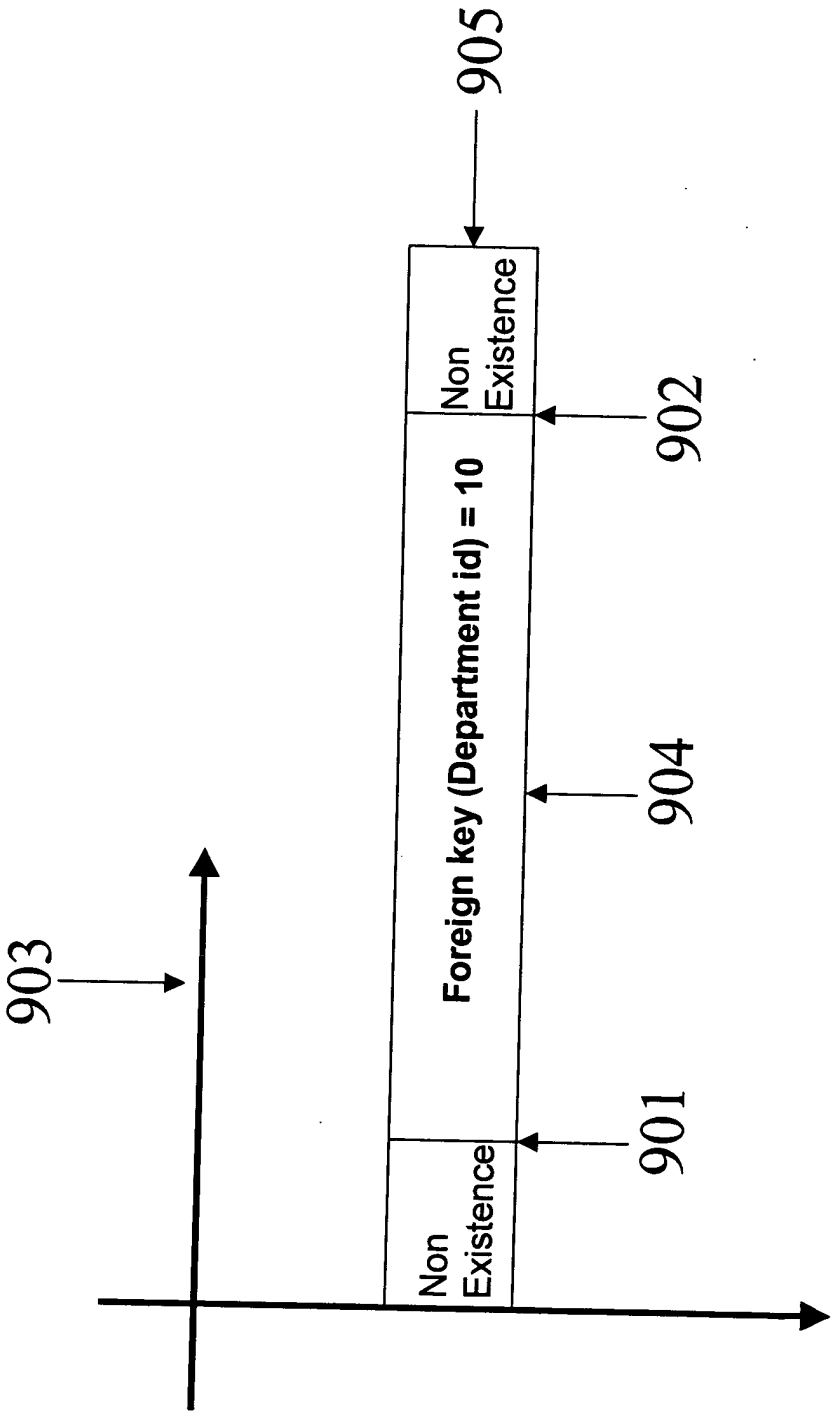

905
Non Existence
902
Foreign key (Department id) = 10
904
903
901
Non Existence

FIG. 9

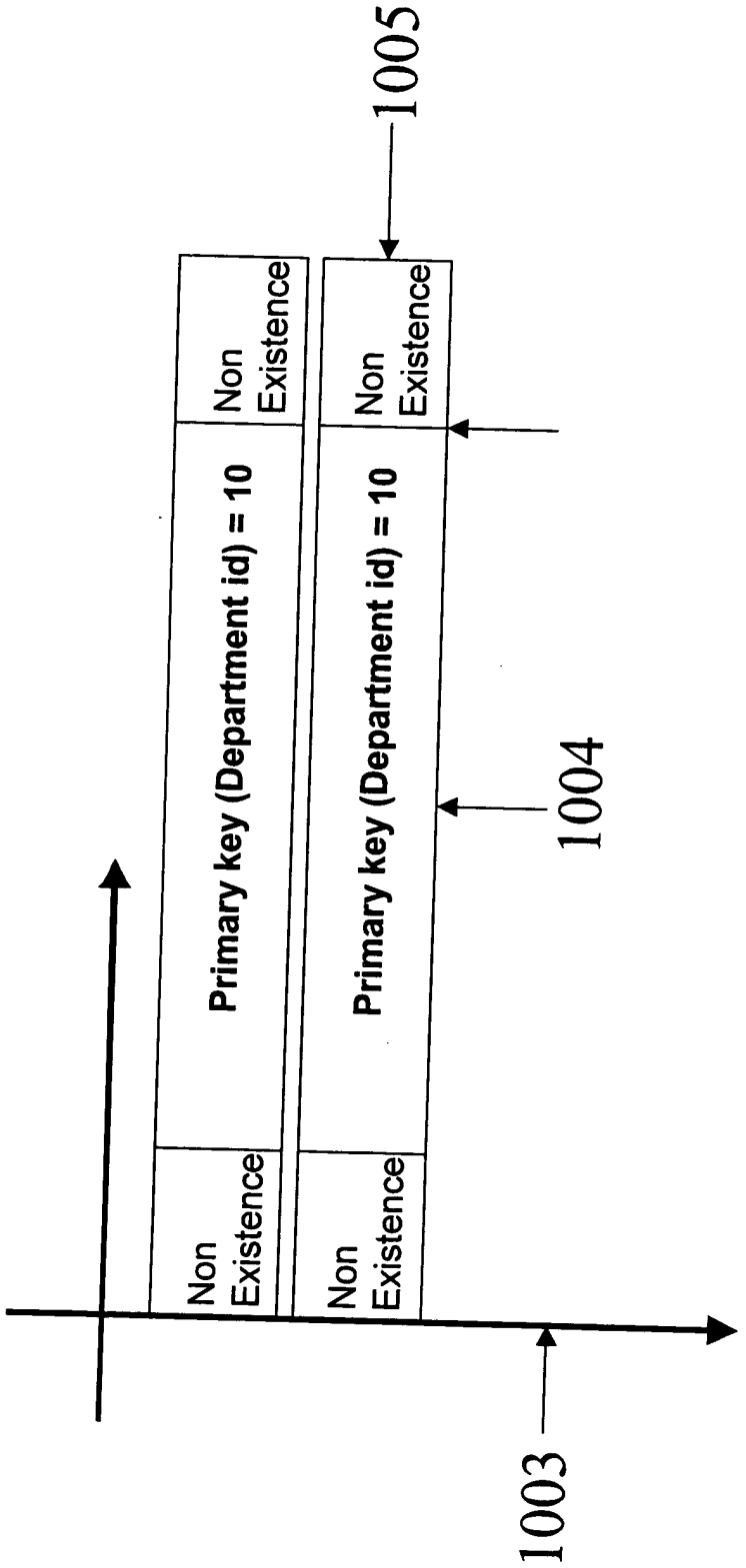

1005
Non Existence
Primary key (Department id) = 10
Non Existence
Primary key (Department id) = 10
1004
Non Existence
Non Existence
1003

FIG. 10

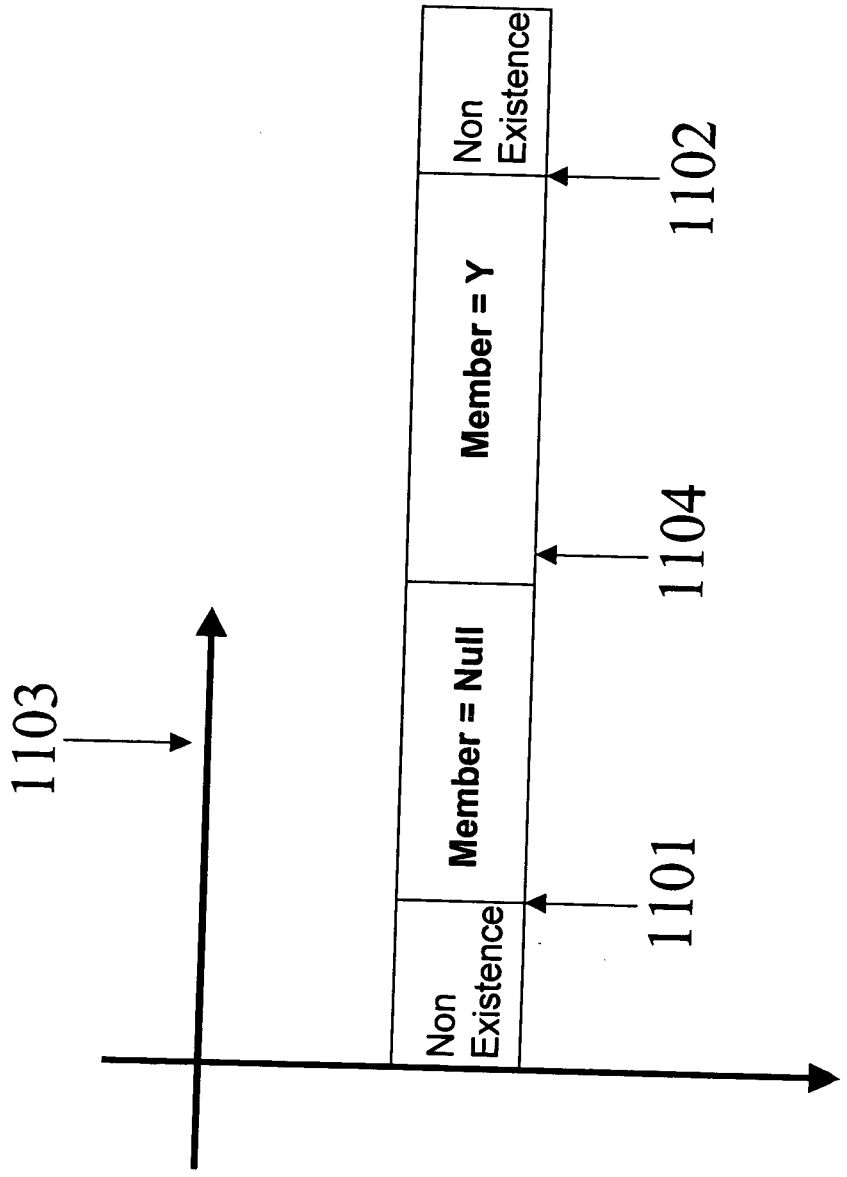

1103
Non Existence
Member = Null
Member = Y
Non Existence
1101
1104
1102

FIG. 11

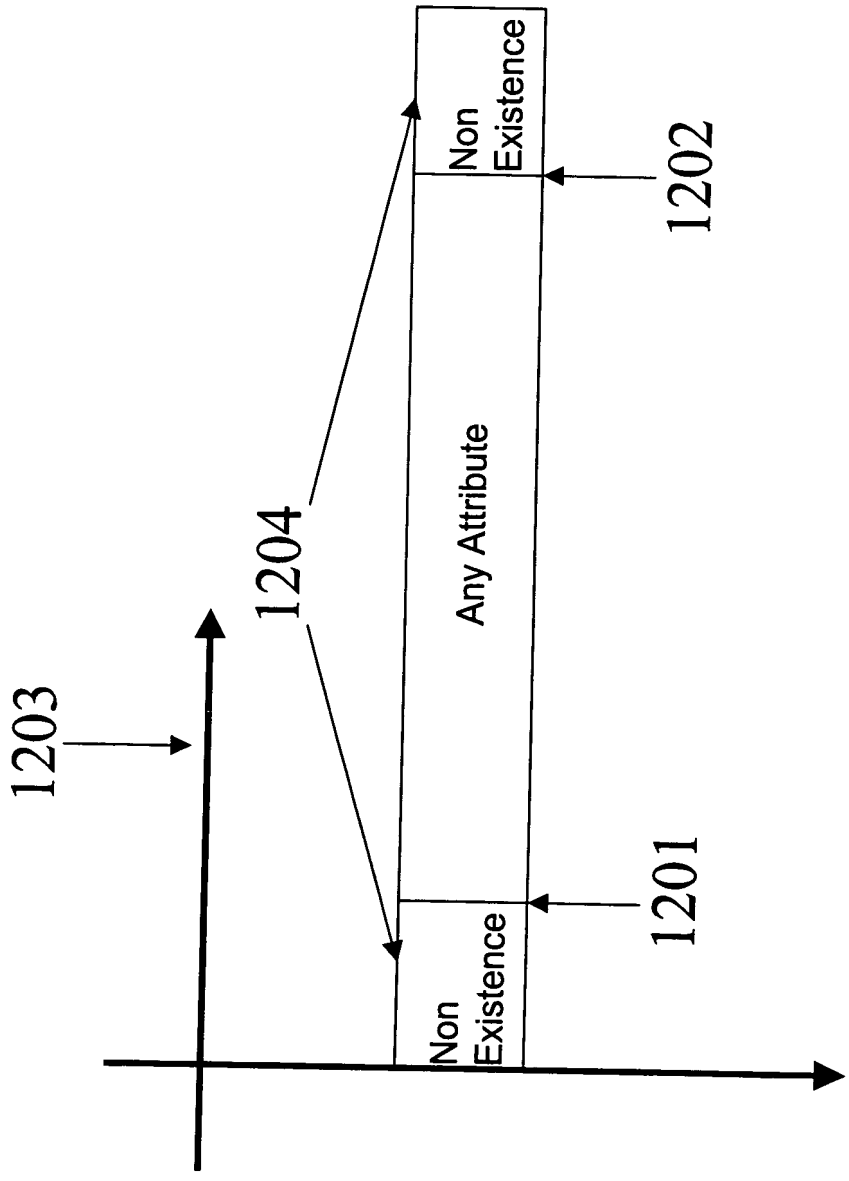

1203
1204
Non Existence
Any Attribute
Non Existence
1202
1201

FIG. 12

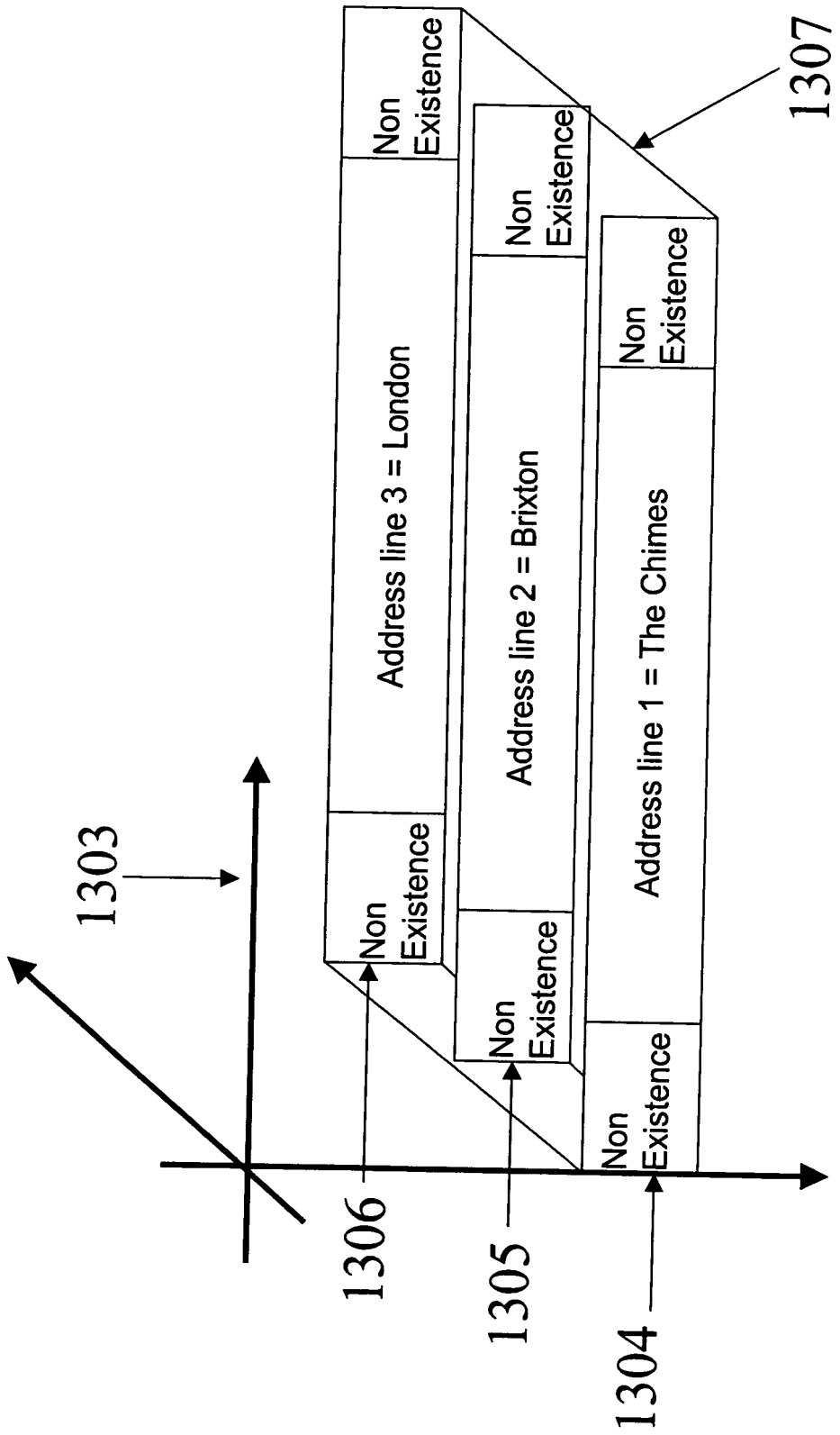

1303
1306
1305
1304
1307
Non Existence
Address line 3 = London
Non Existence
Address line 2 = Brixton
Non Existence
Address line 1 = The Chimes
Non Existence
Non Existence
Non Existence

FIG. 13

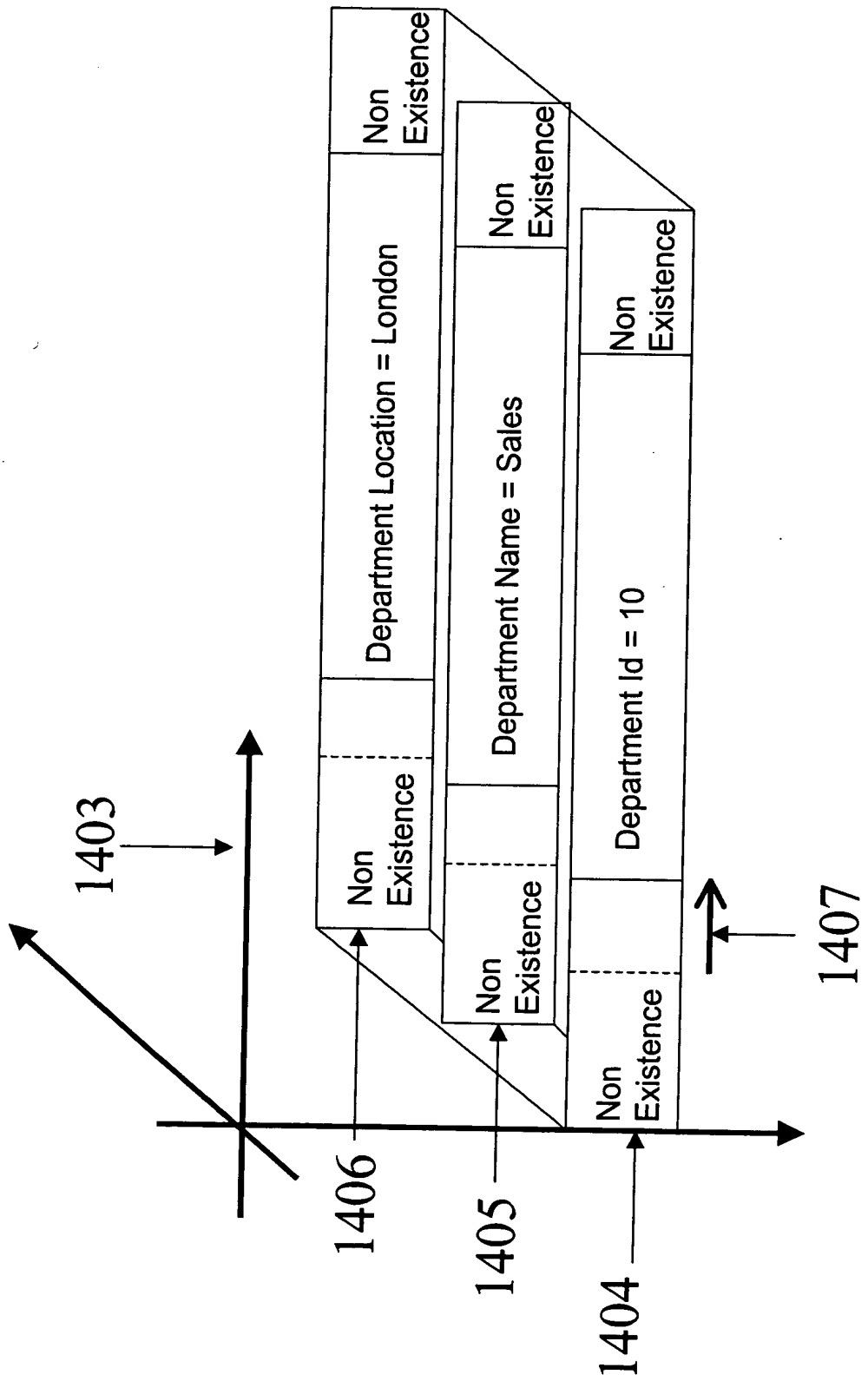

1403
Non Existence
Department Location = London
Non Existence
Non Existence
Department Name = Sales
Non Existence
Non Existence
Department Id = 10
Non Existence
1406
1405
1404
1407

FIG. 14

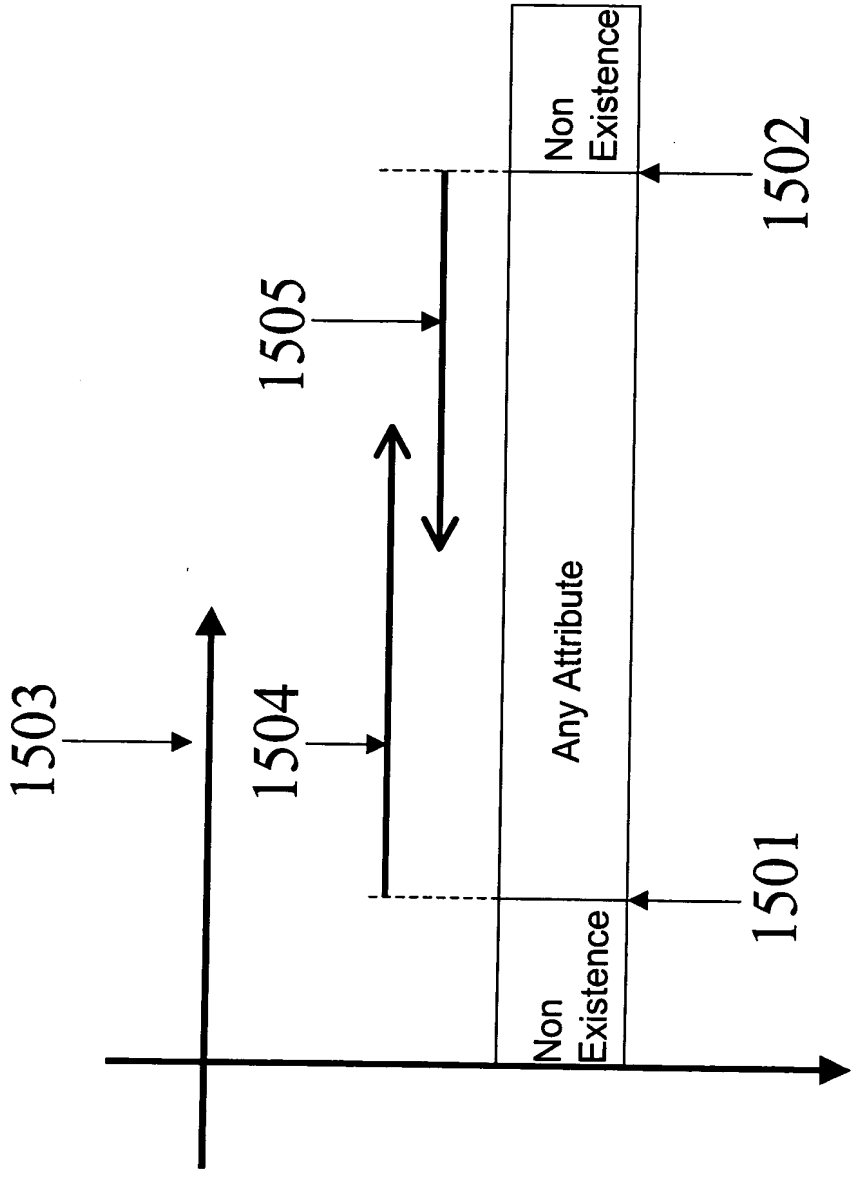

Non Existence
1502
1505
1503
1504
Any Attribute
1501
Non Existence

FIG. 15

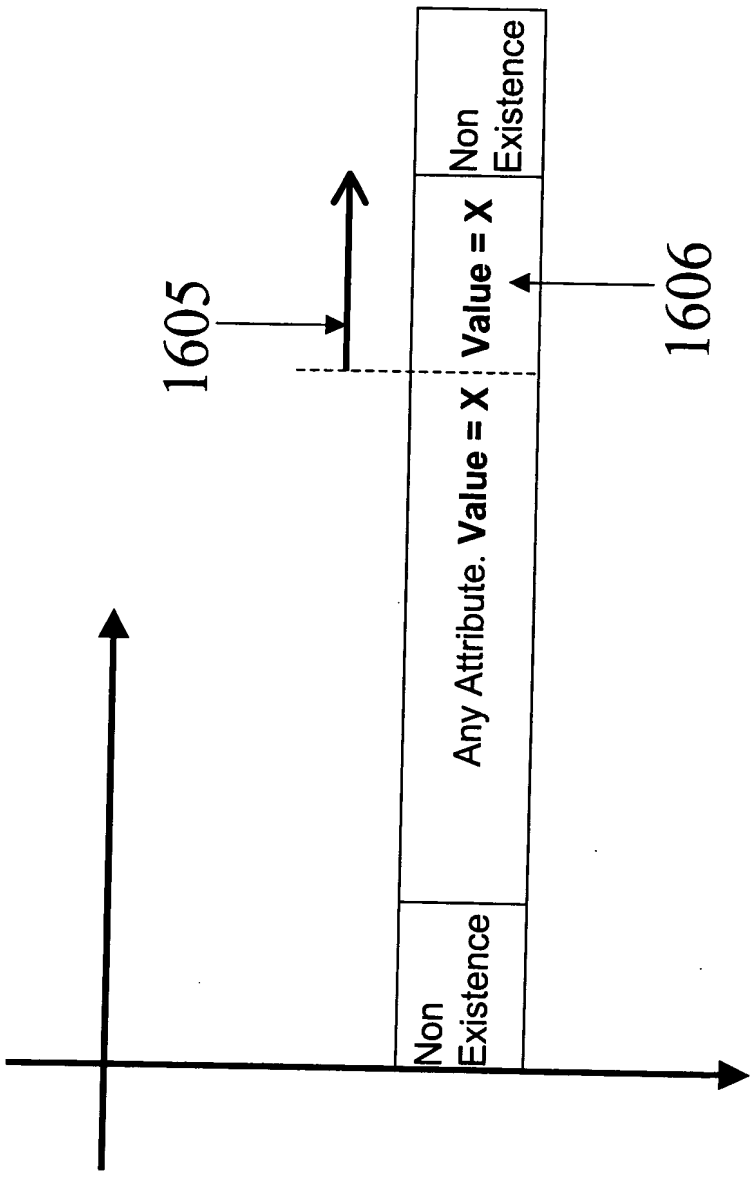

Non Existence
Value = X
Any Attribute. Value = X
Non Existence
1605
1606

FIG. 16a

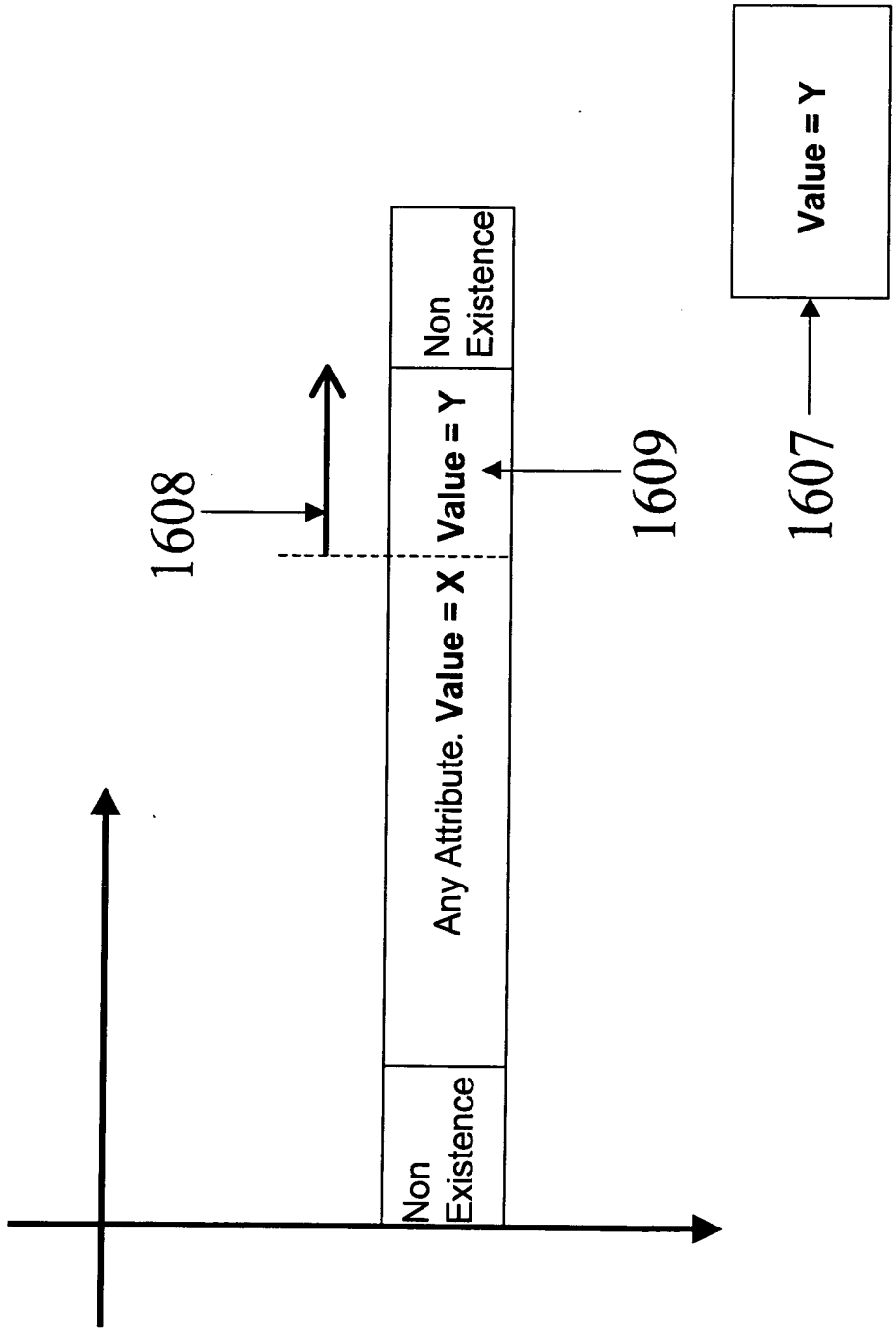

Value = Y
1607
1609
1608
Non Existence
Value = Y
Any Attribute. Value = X
Non Existence

FIG. 16b

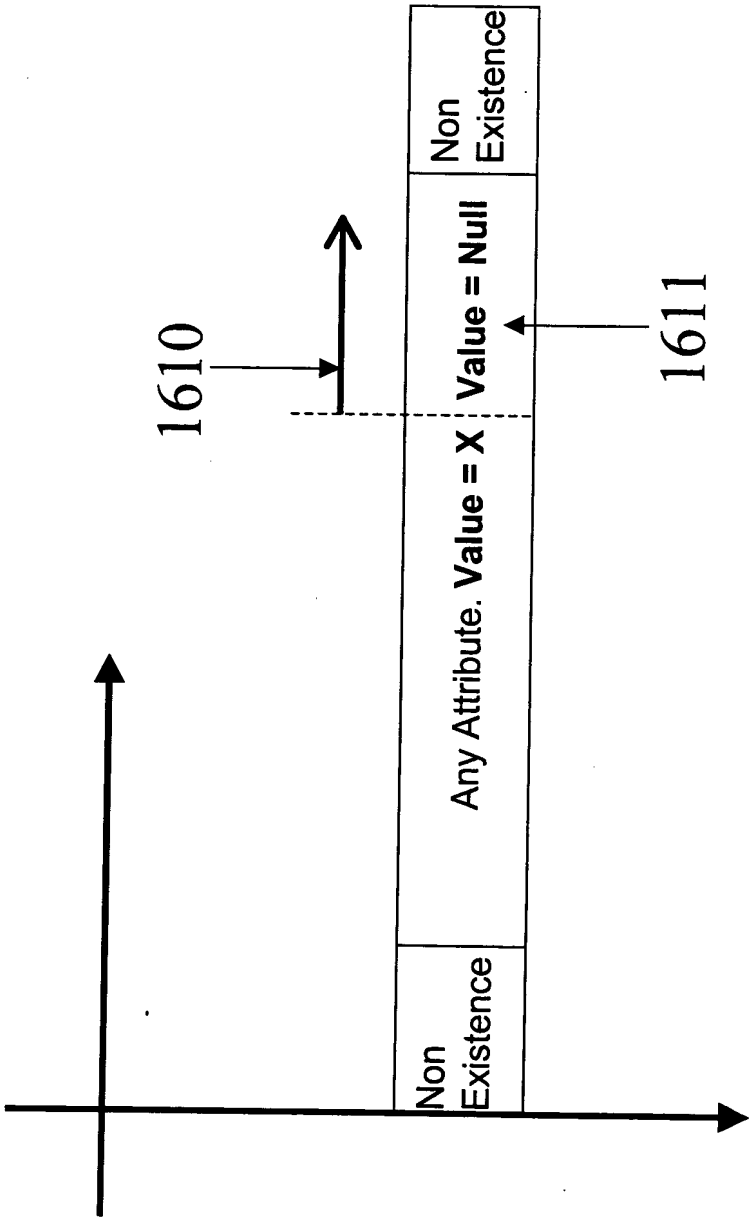

Non Existence
Value = Null
Any Attribute. Value = X
Non Existence
1610
1611

FIG. 16c

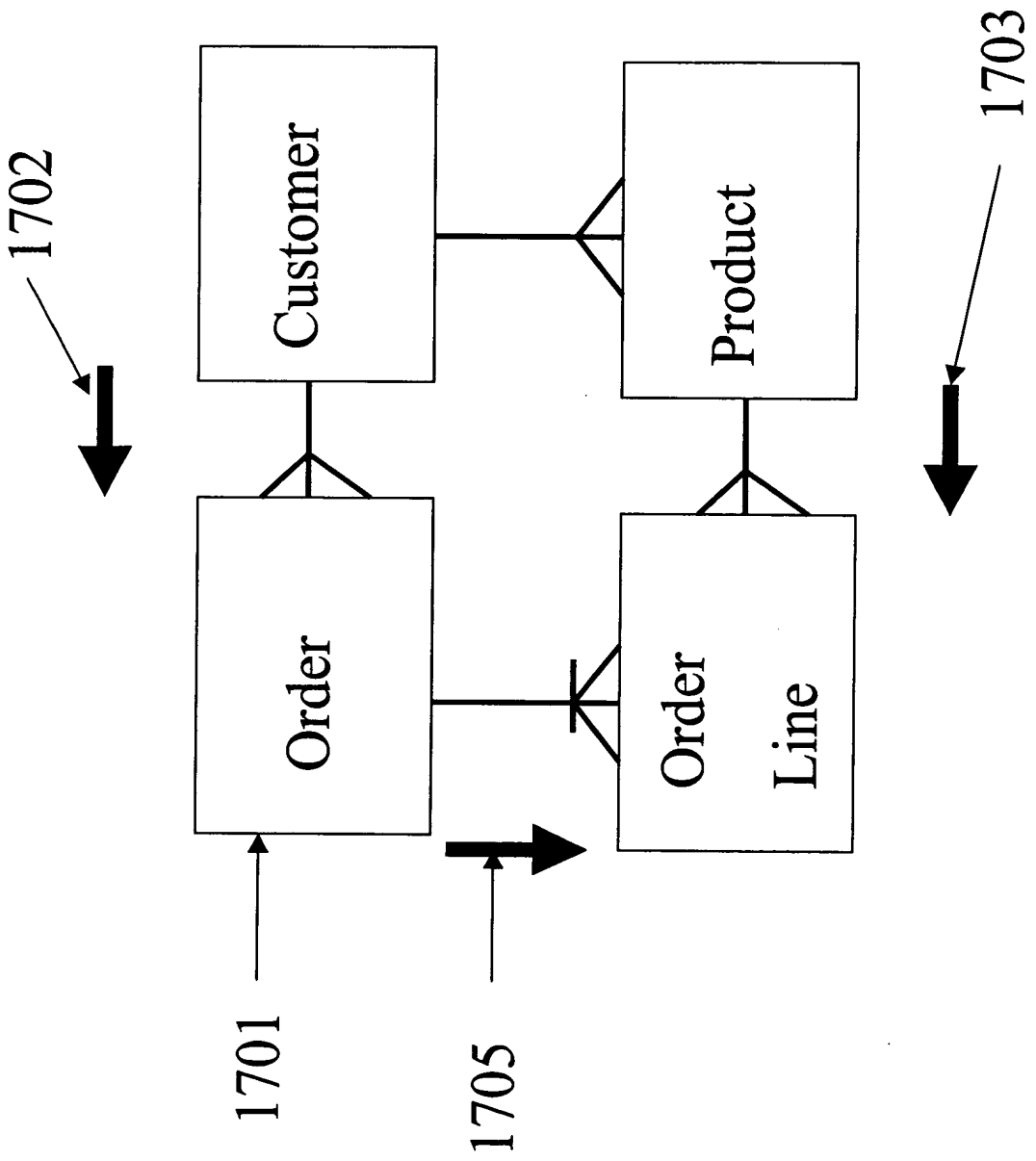


FIG. 17

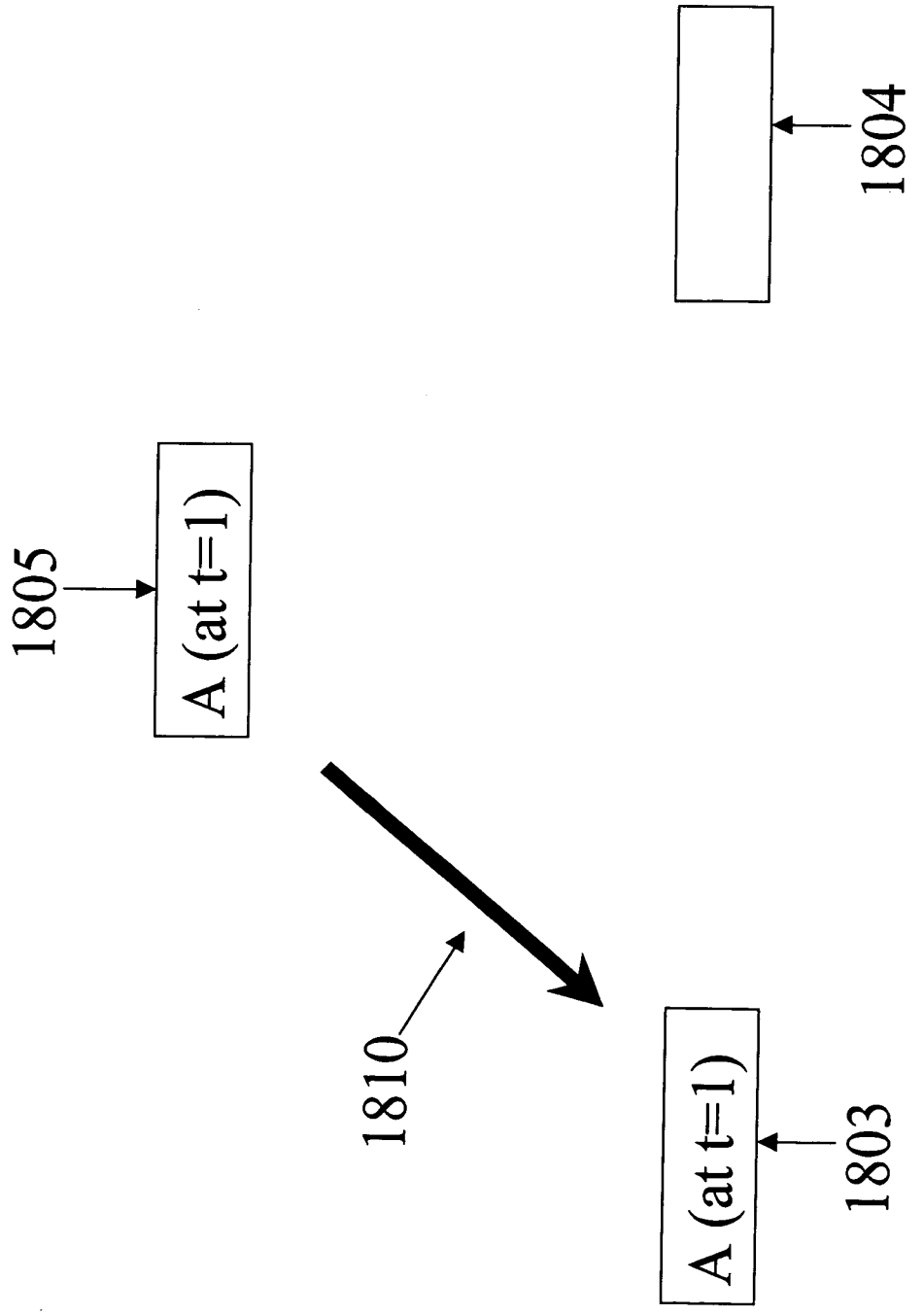


FIG. 18a

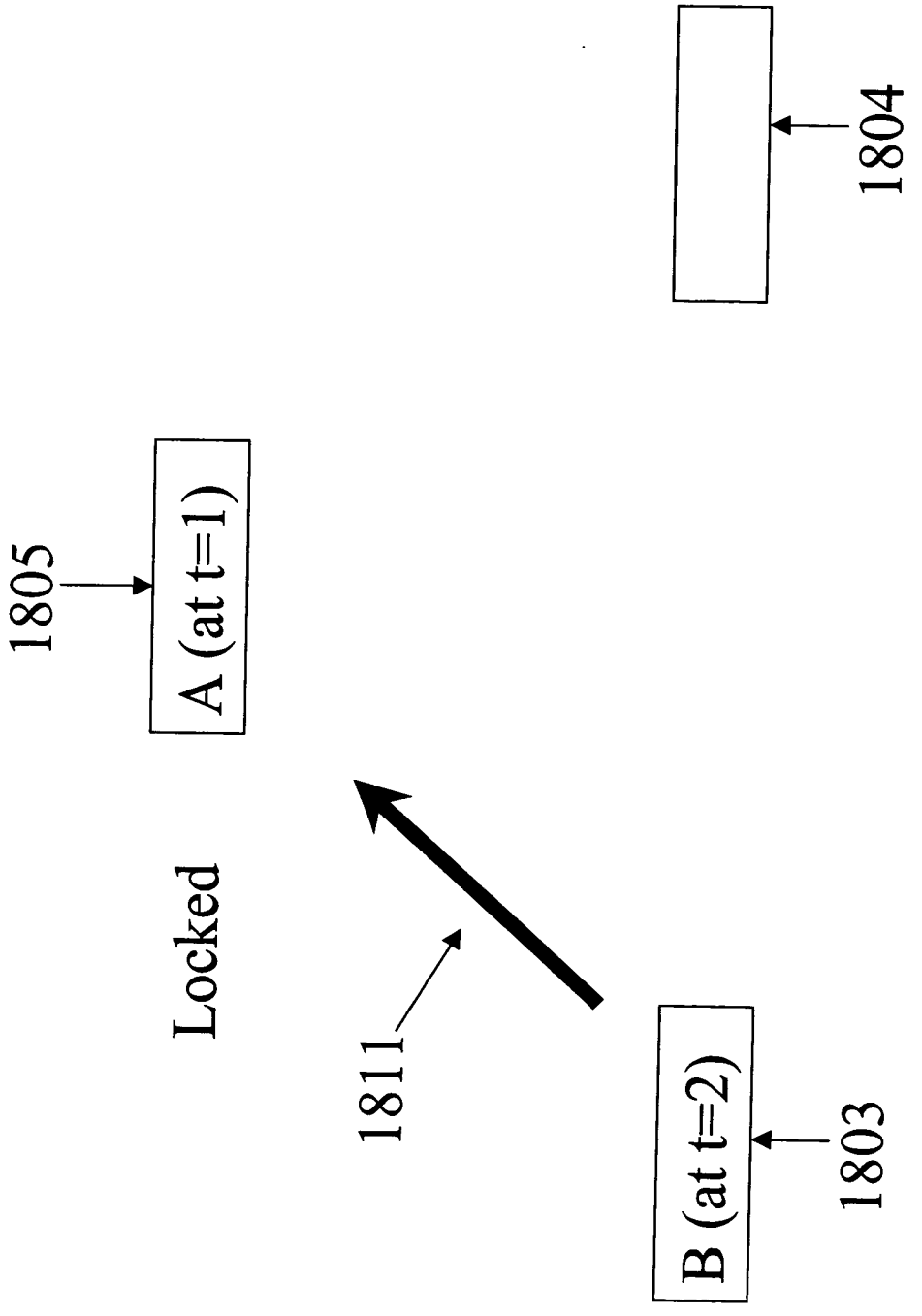


FIG. 18b

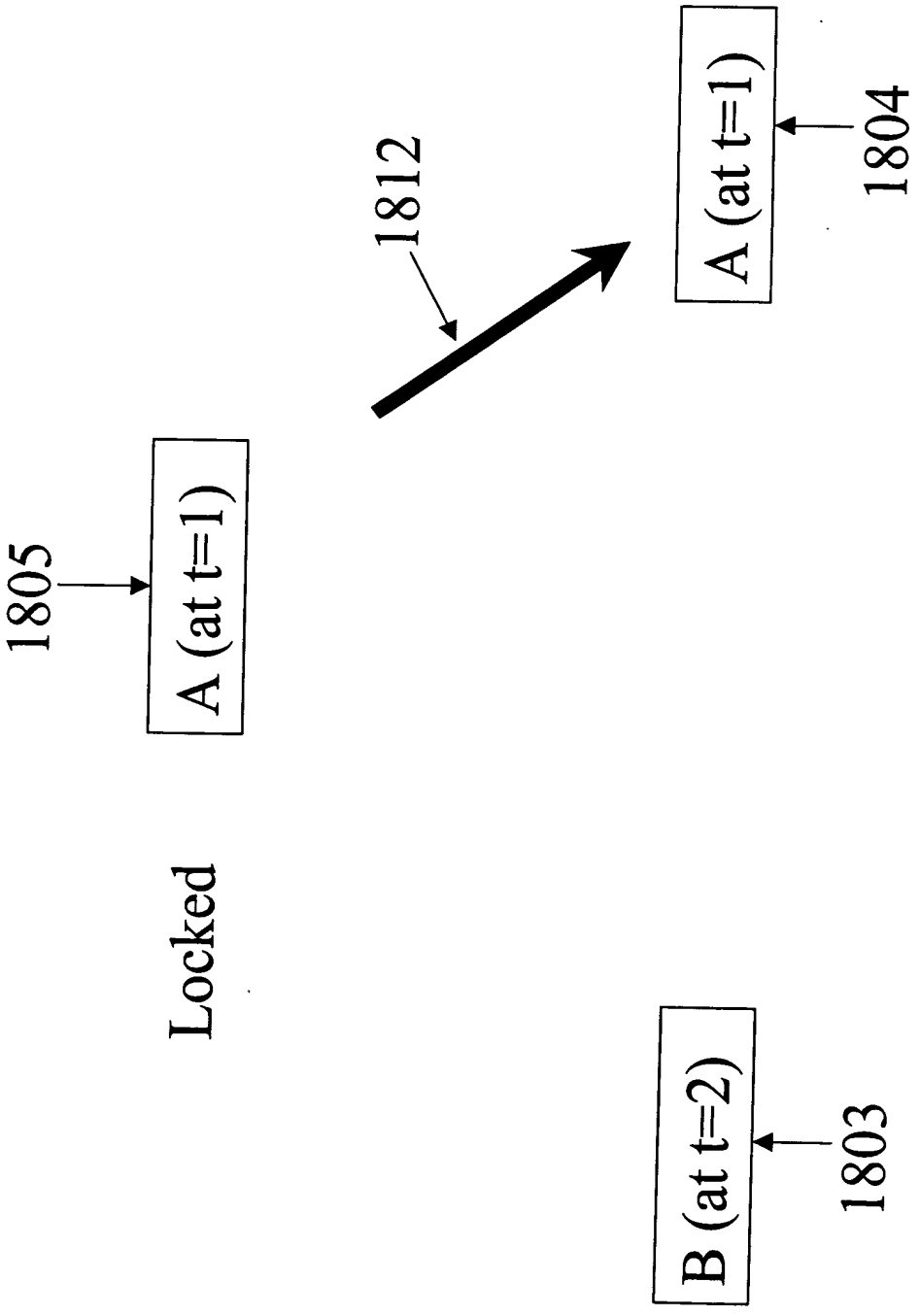


FIG. 18c

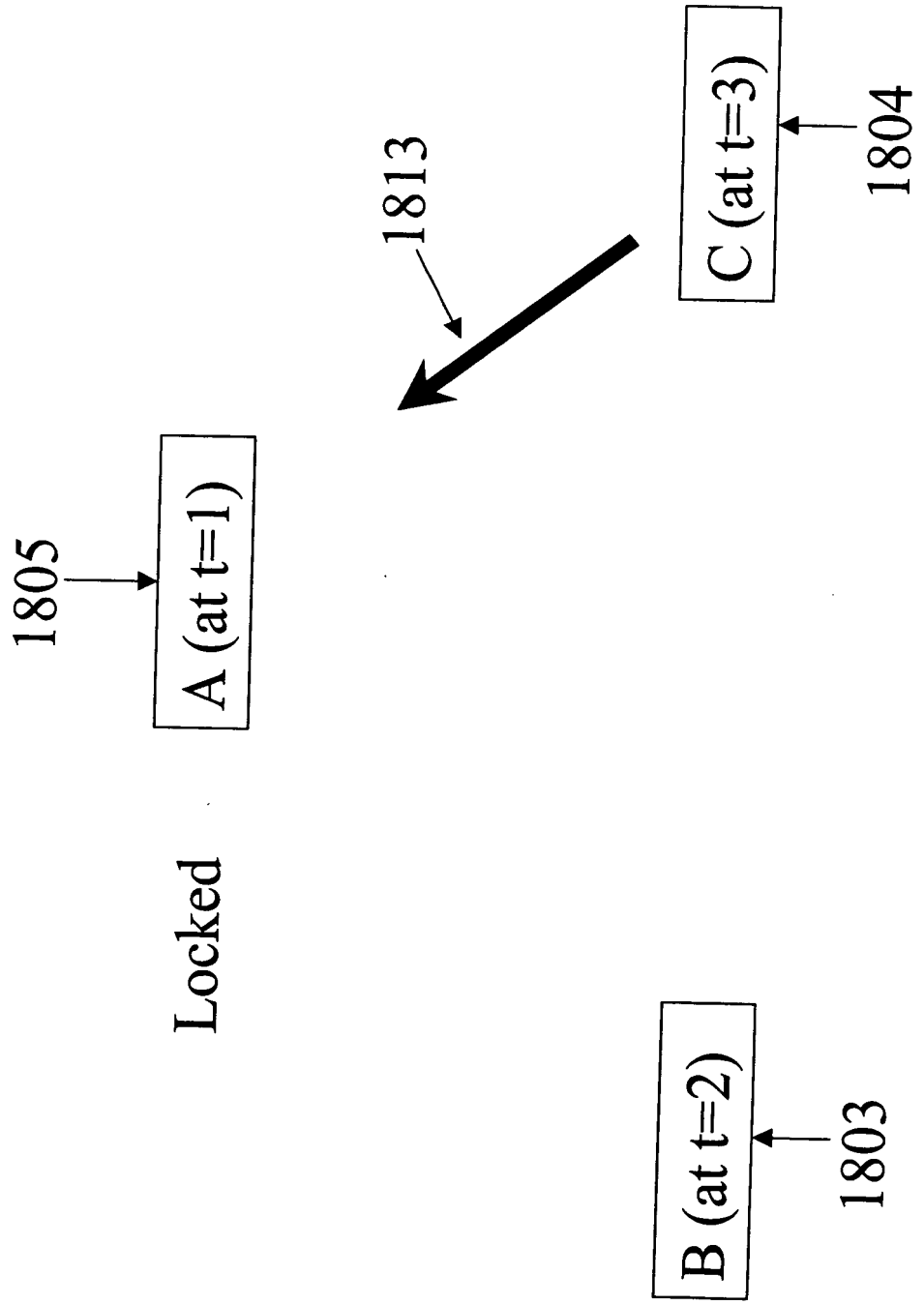


FIG. 18d

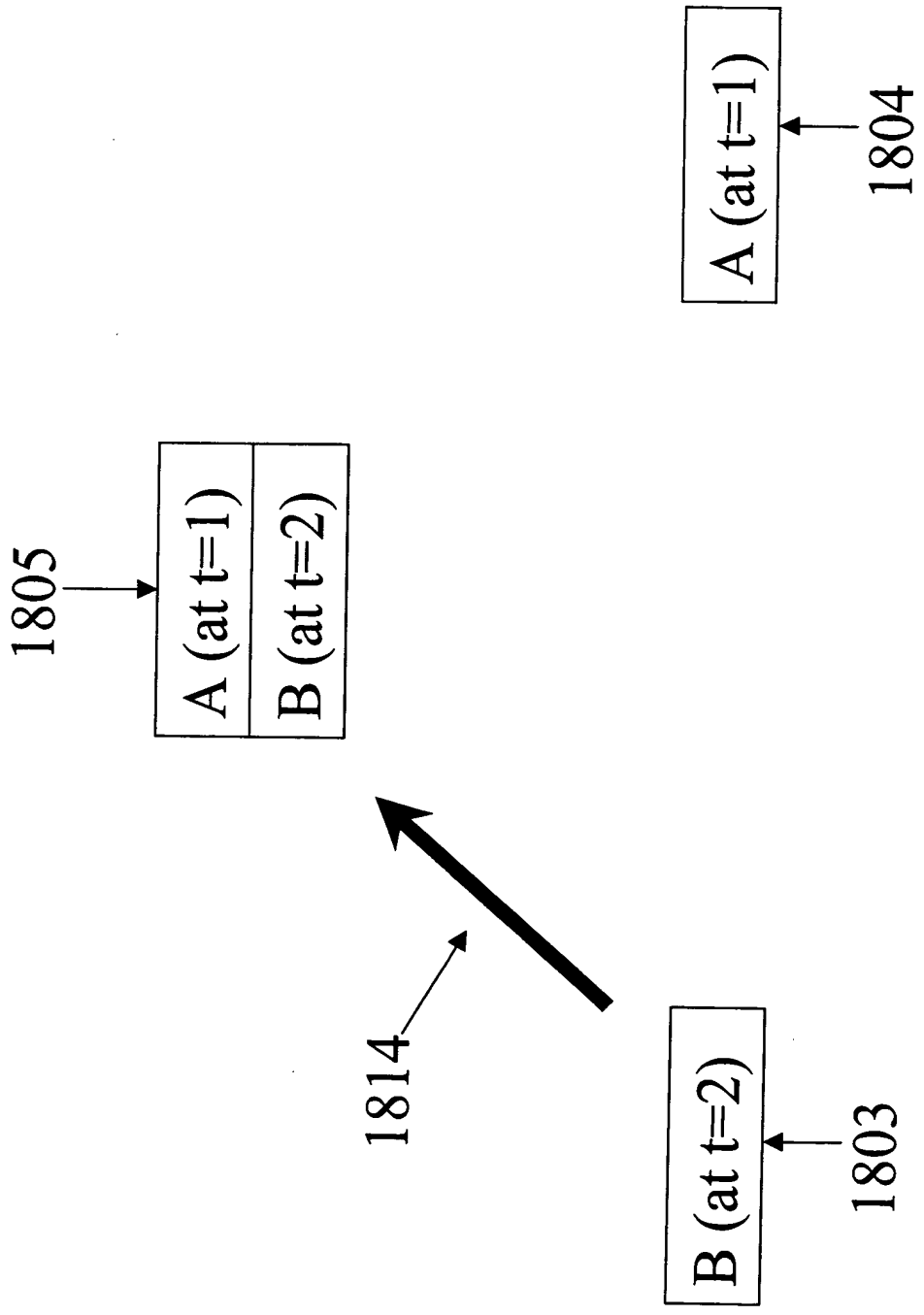


FIG. 18e

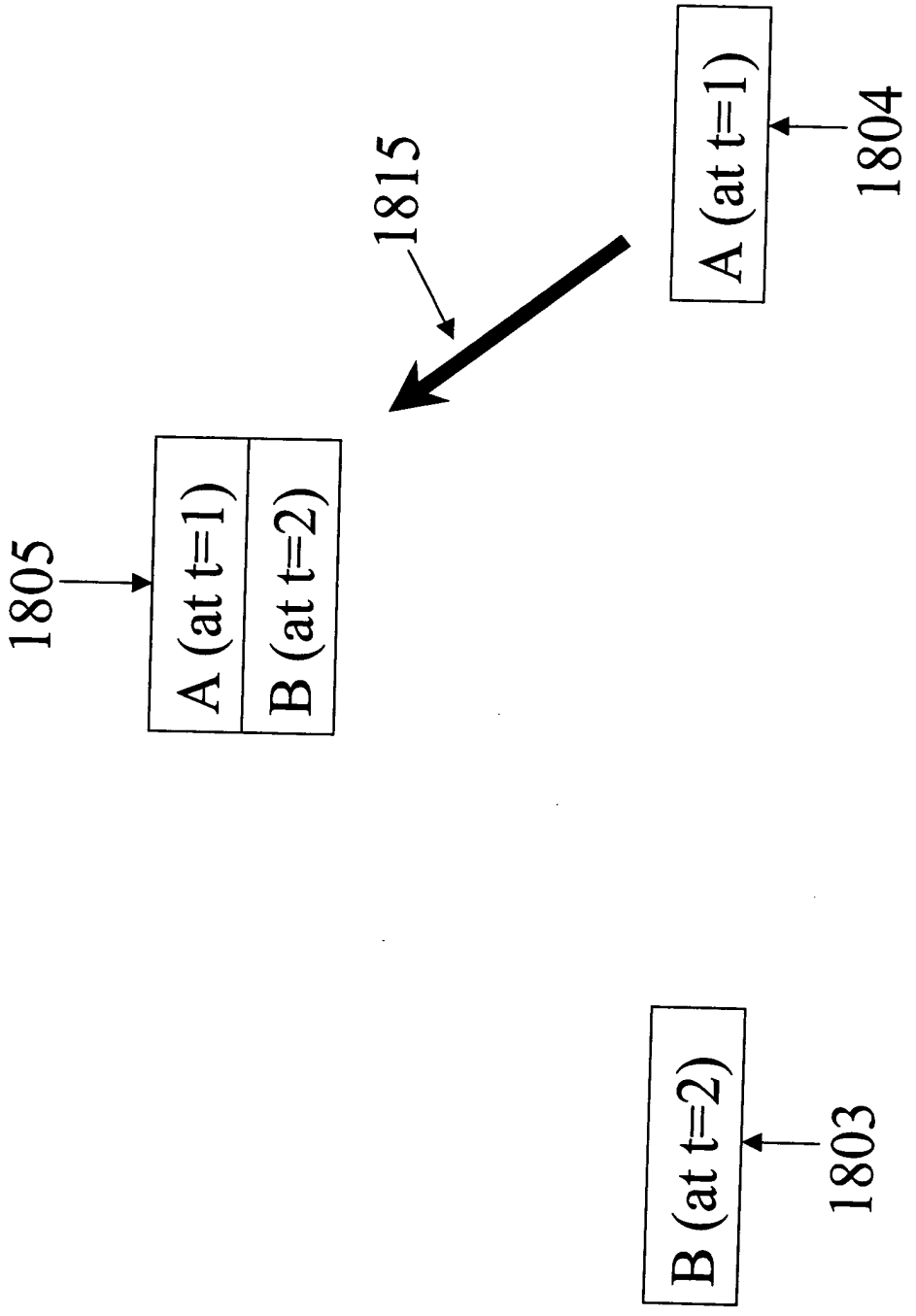


FIG. 18f

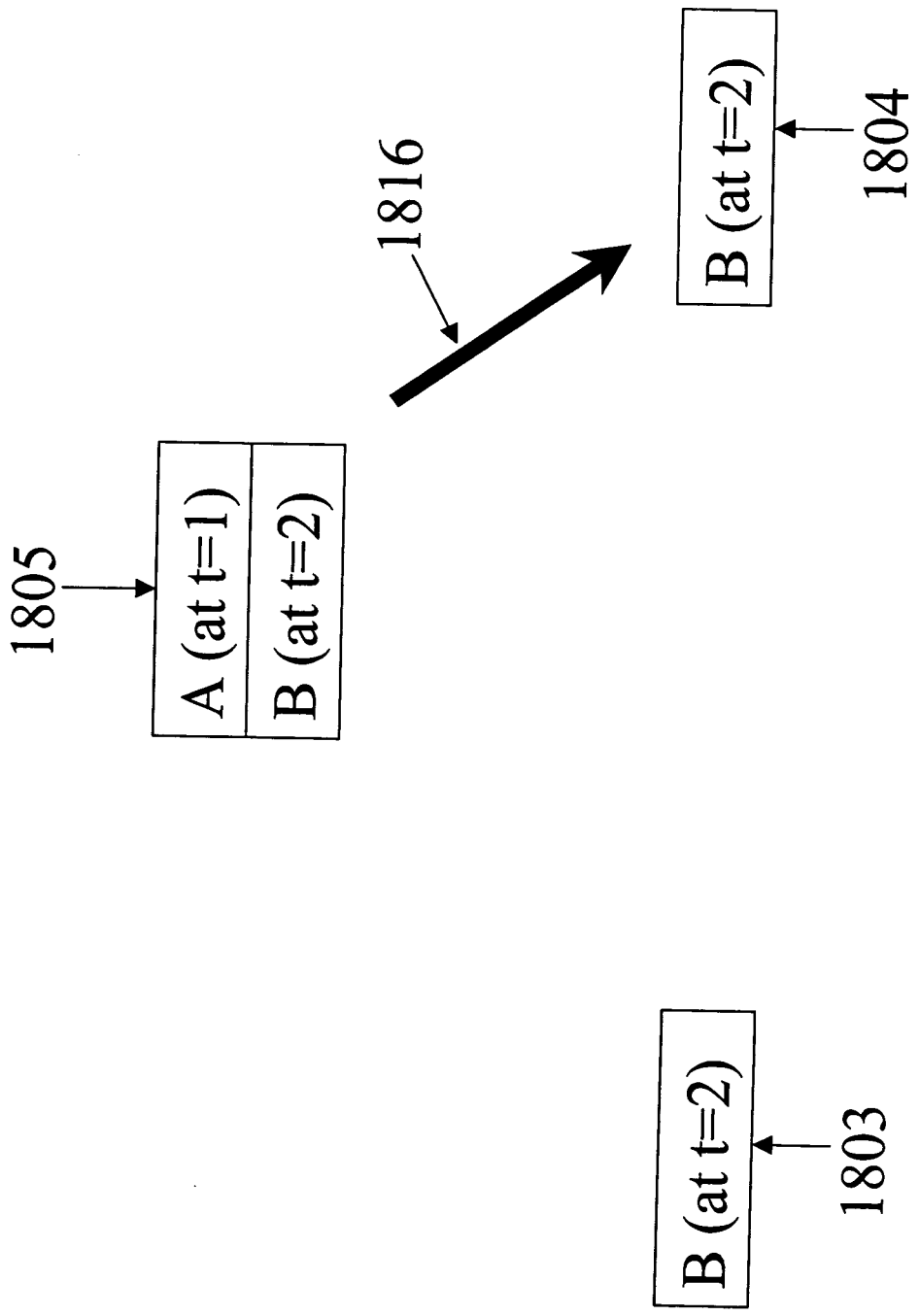


FIG. 18g

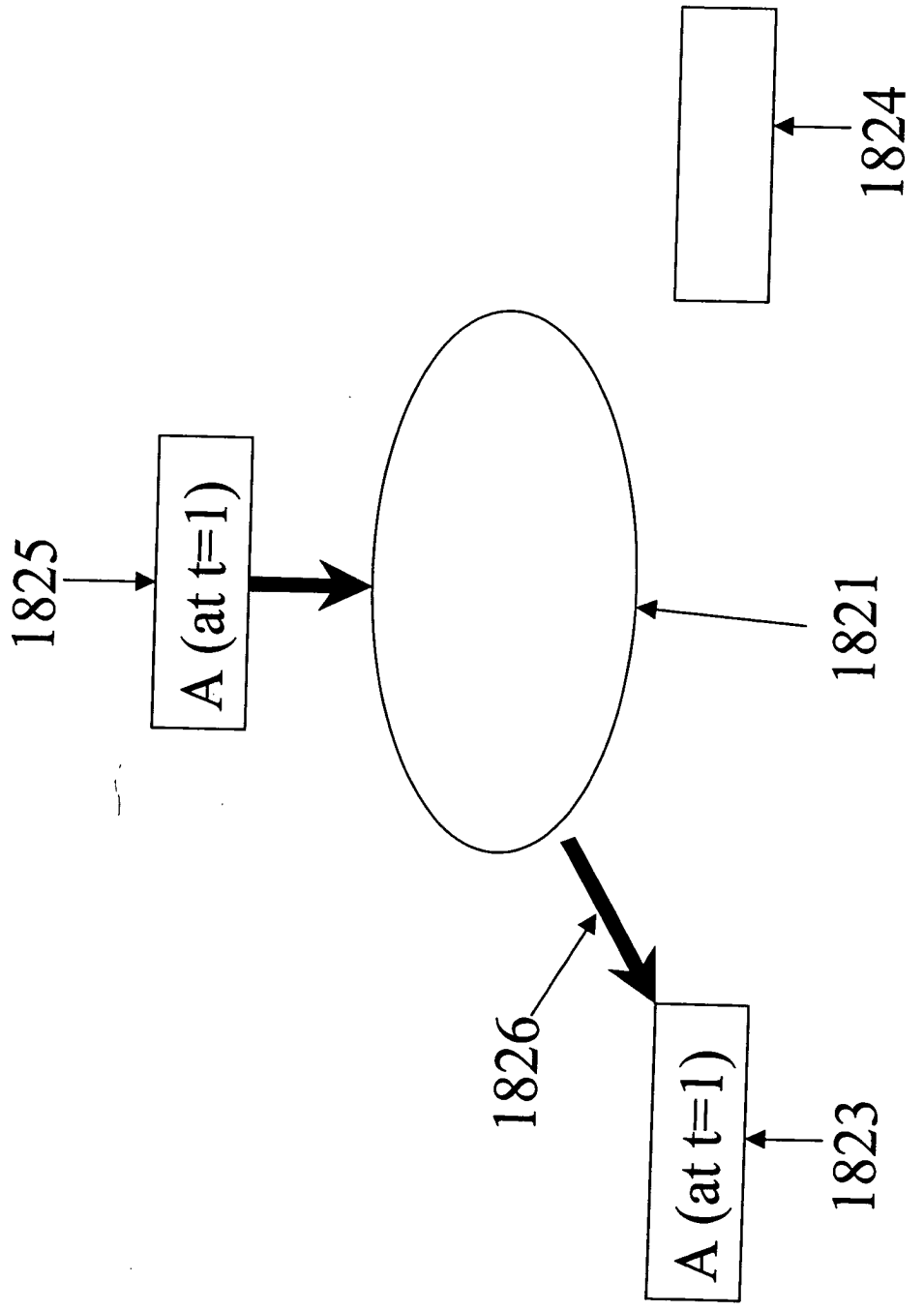


FIG. 18h

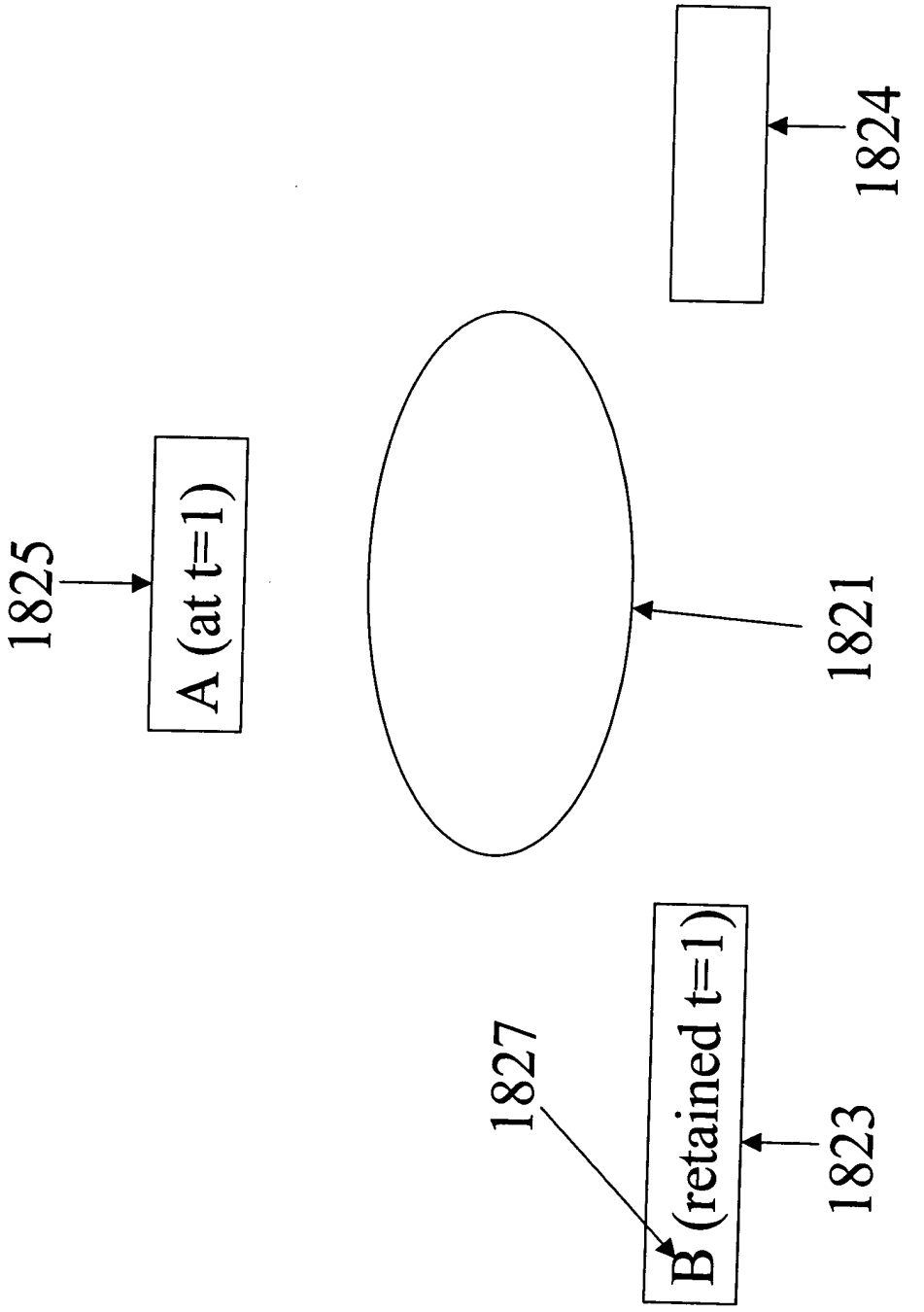


FIG. 18i

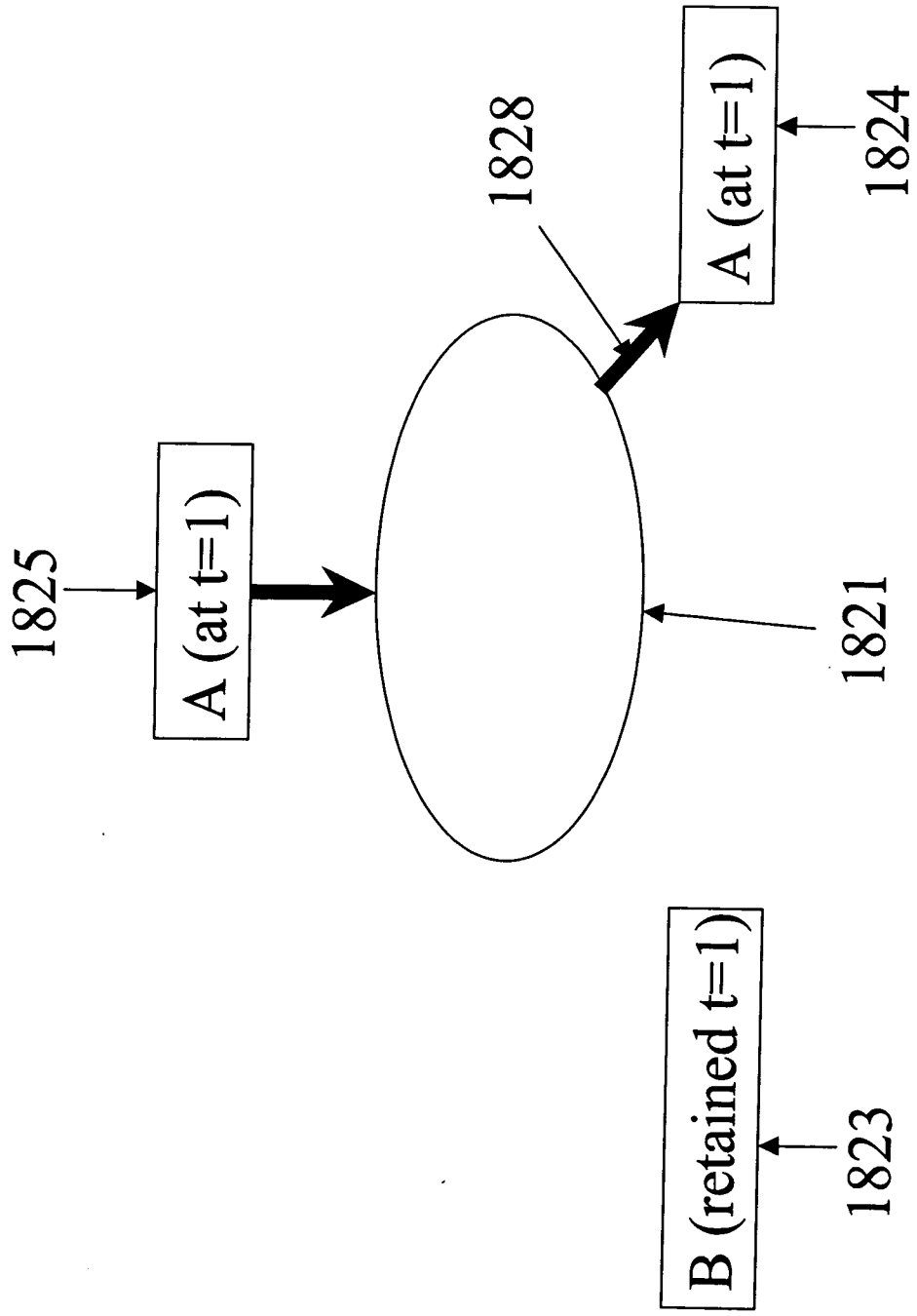


FIG. 18j

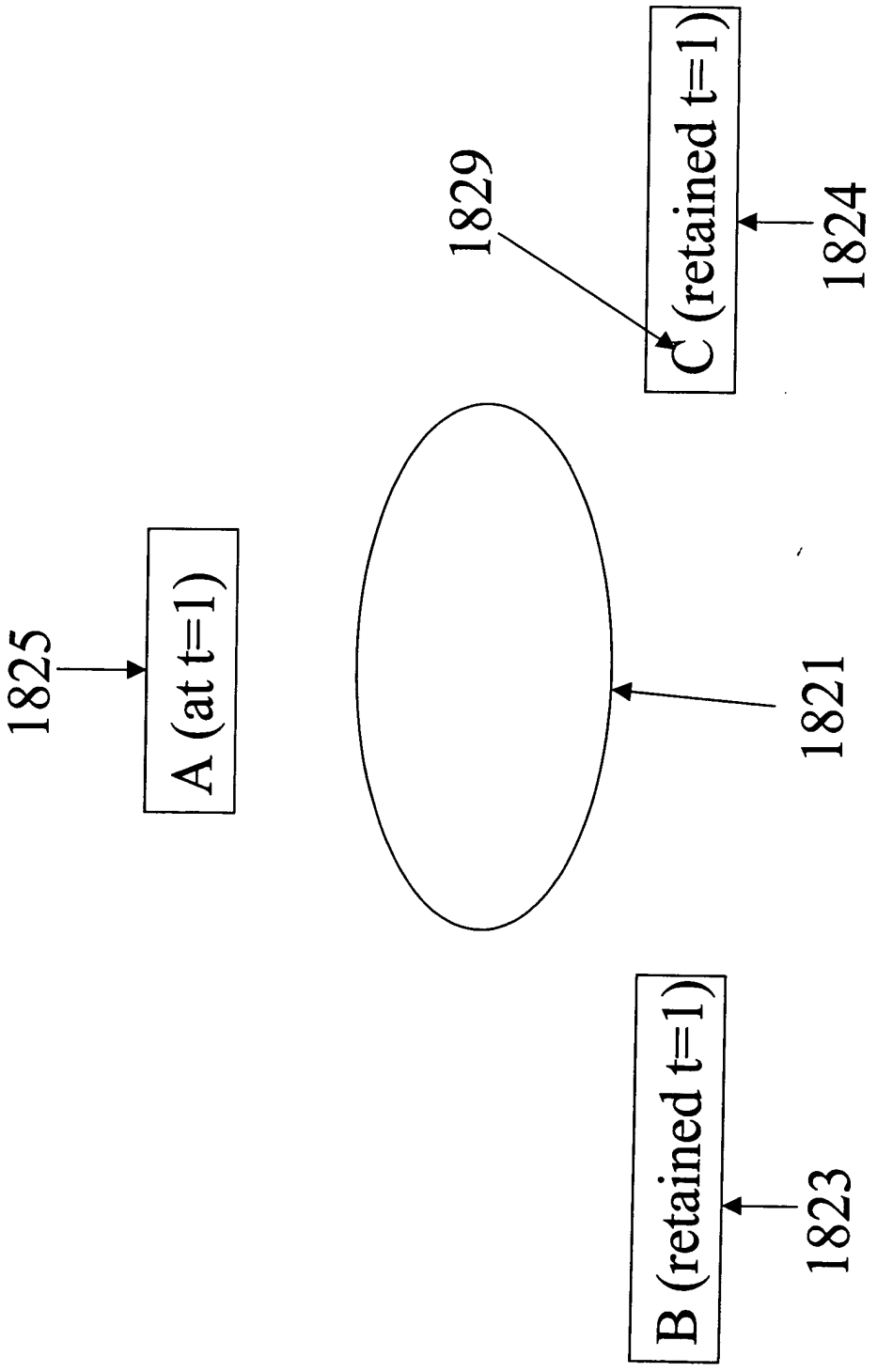


FIG. 18k

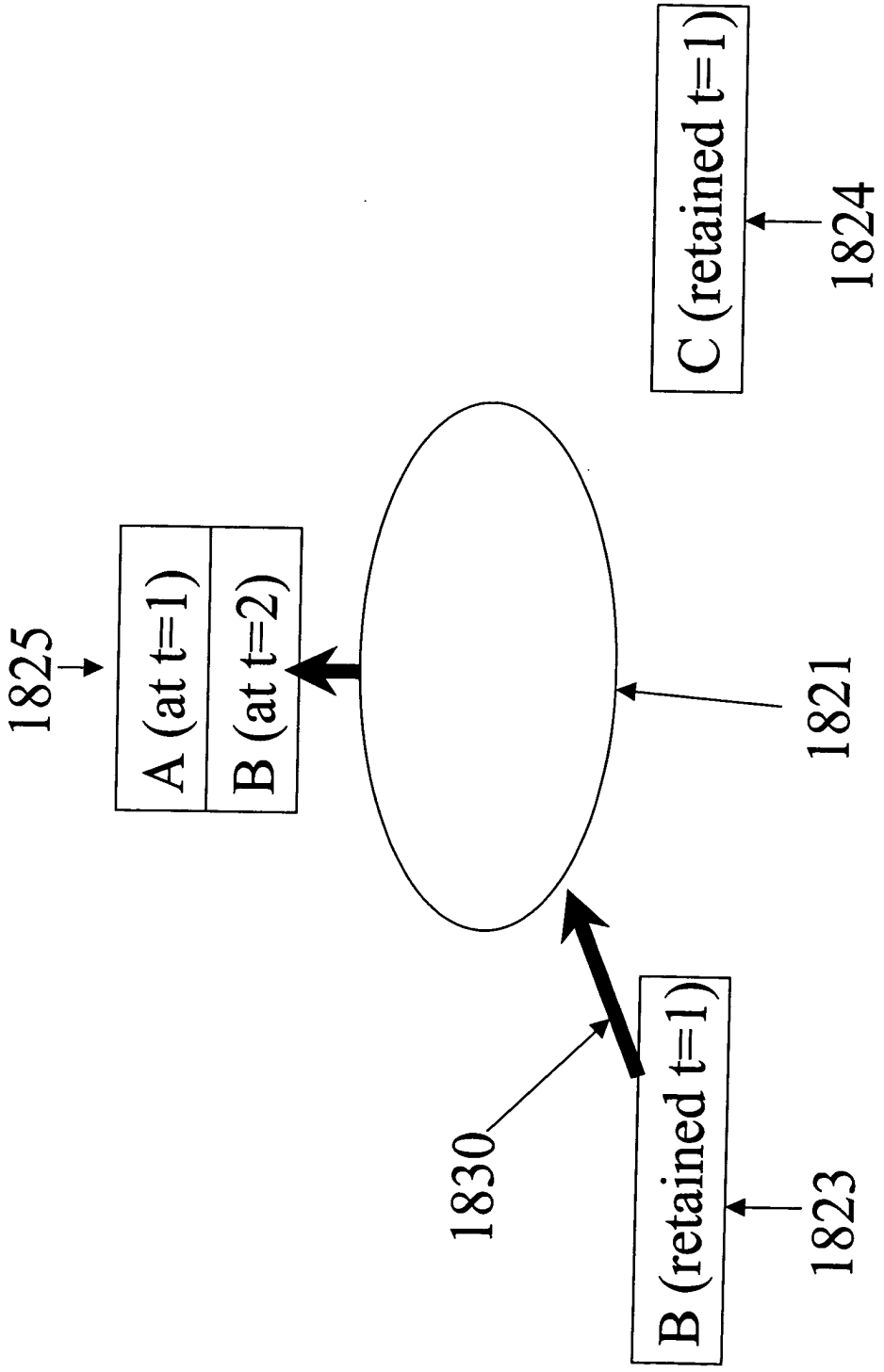

1825
A (at t=1)
B (at t=2)
C (retained t=1)
1824
1821
1830
B (retained t=1)
1823

FIG. 181

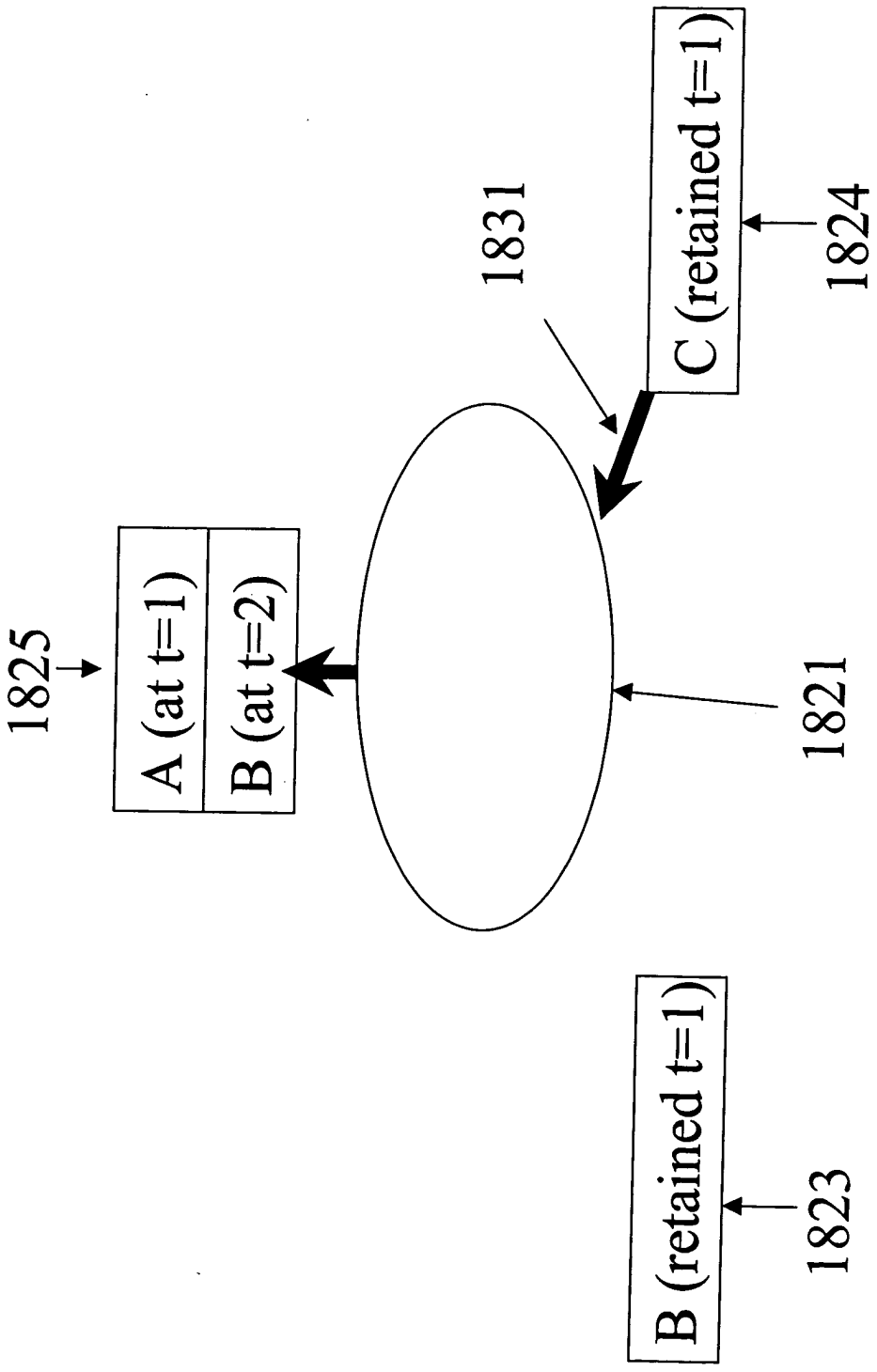

1825
A (at t=1)
B (at t=2)
1831
C (retained t=1)
1824
1821
B (retained t=1)
1823

FIG. 18m

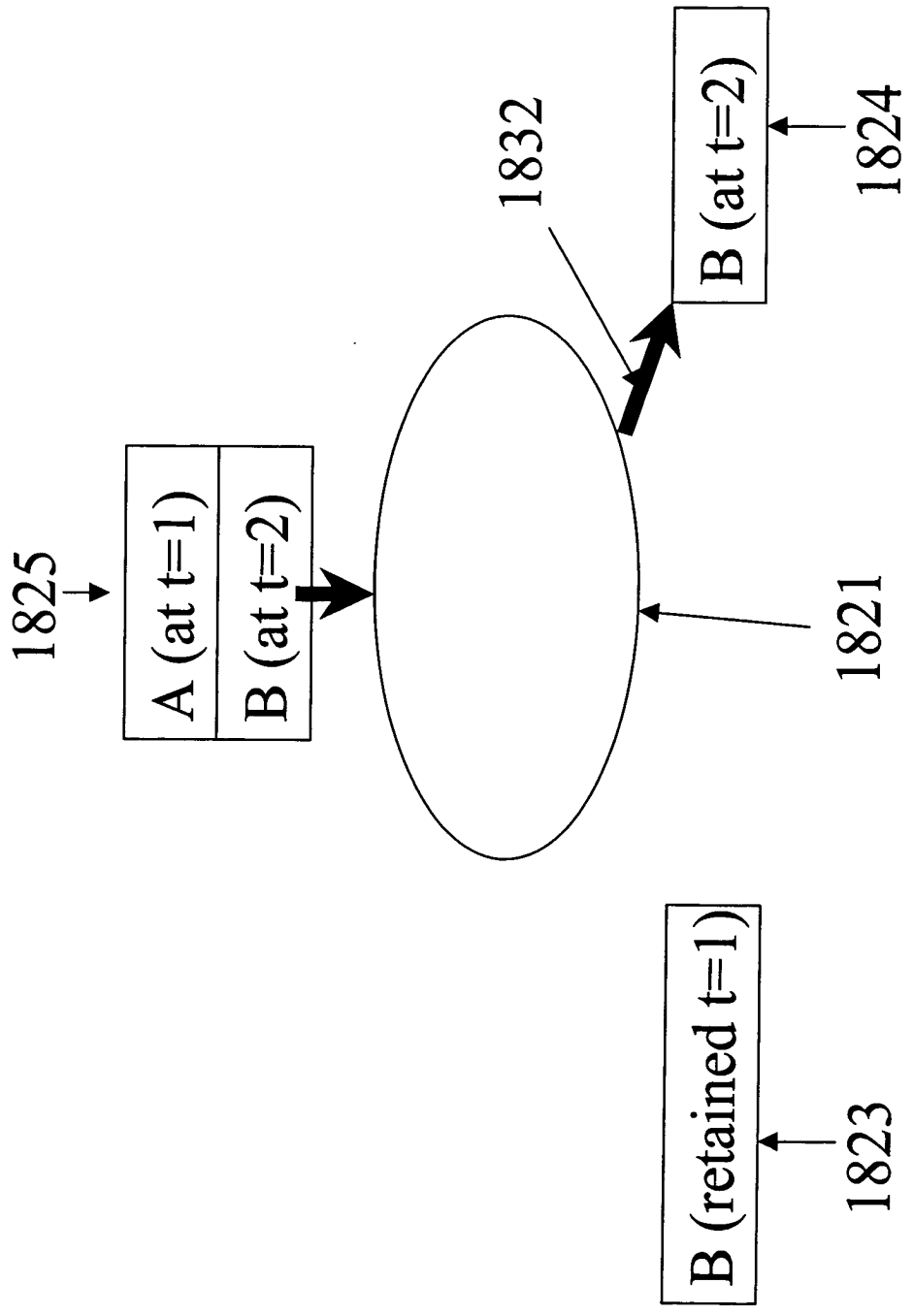


FIG. 18n

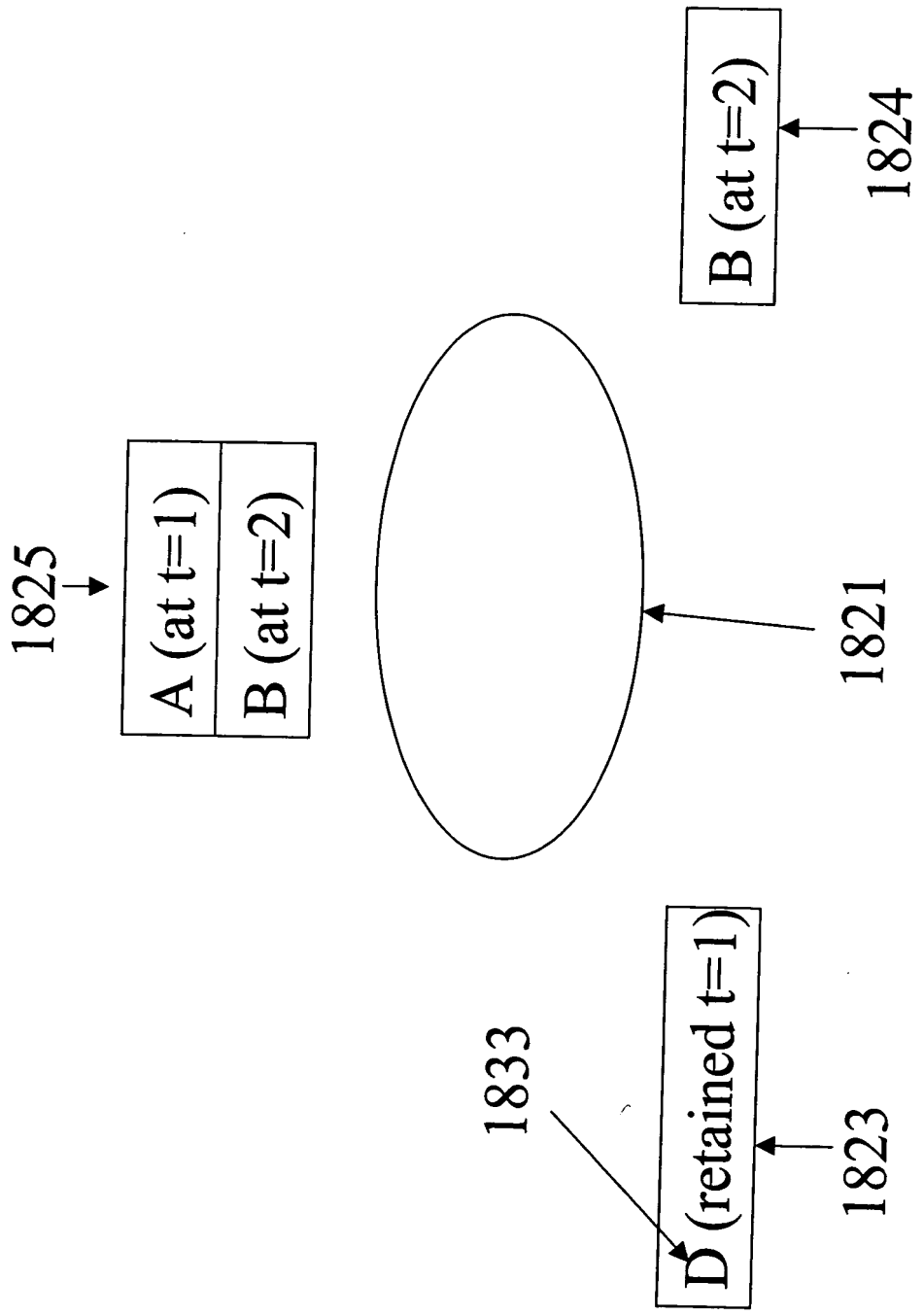


FIG. 18o

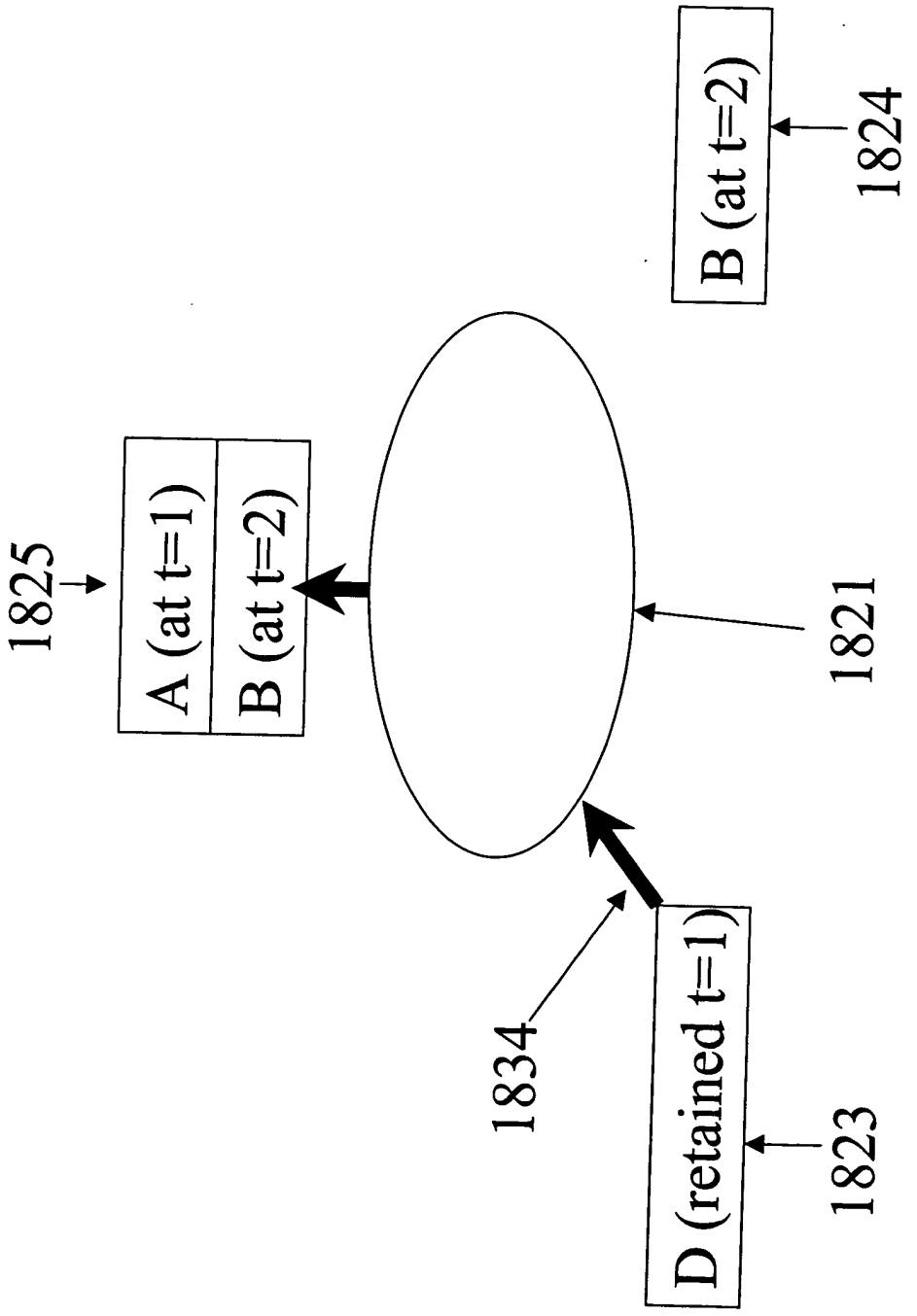


FIG. 18p

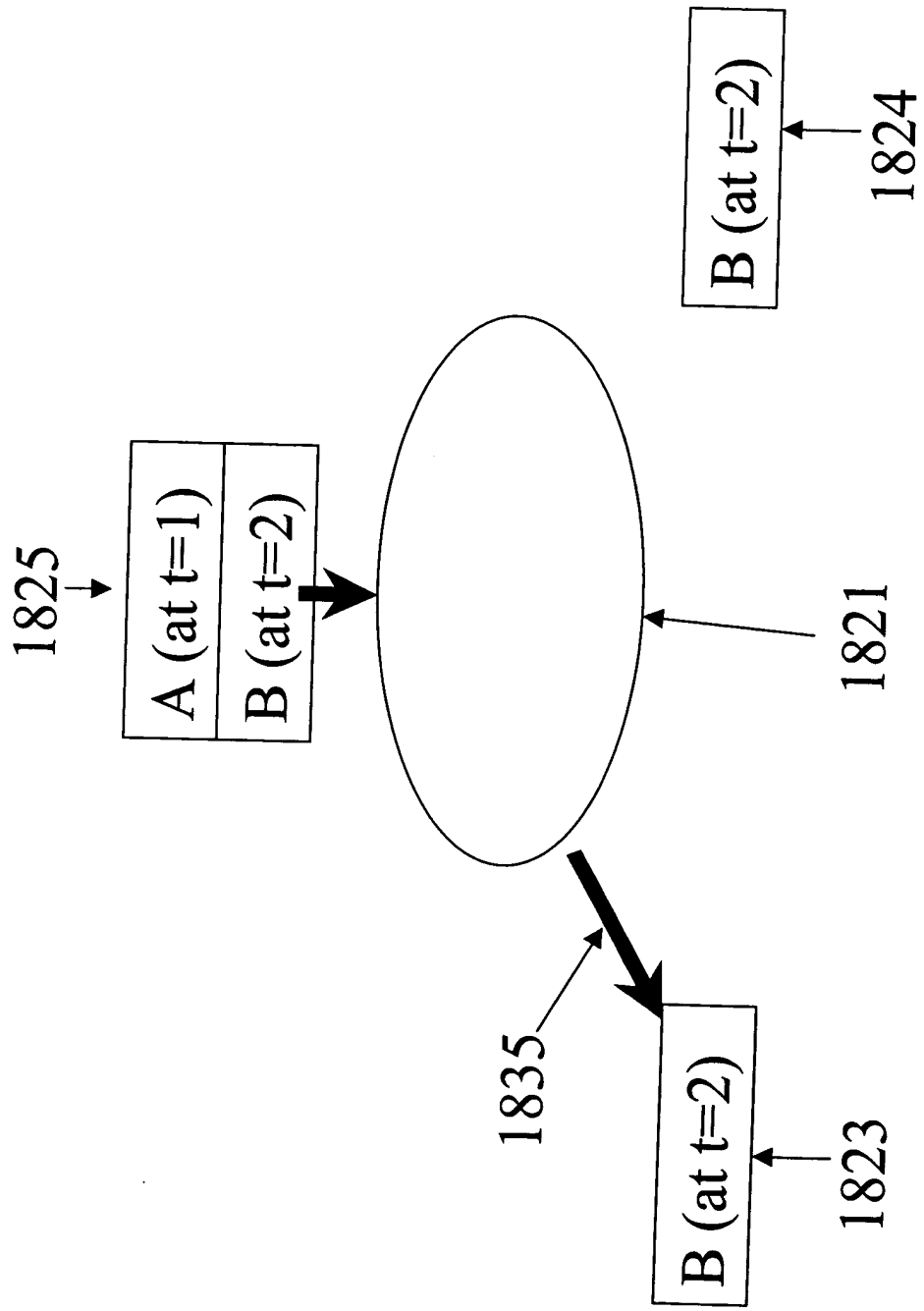


FIG. 18q

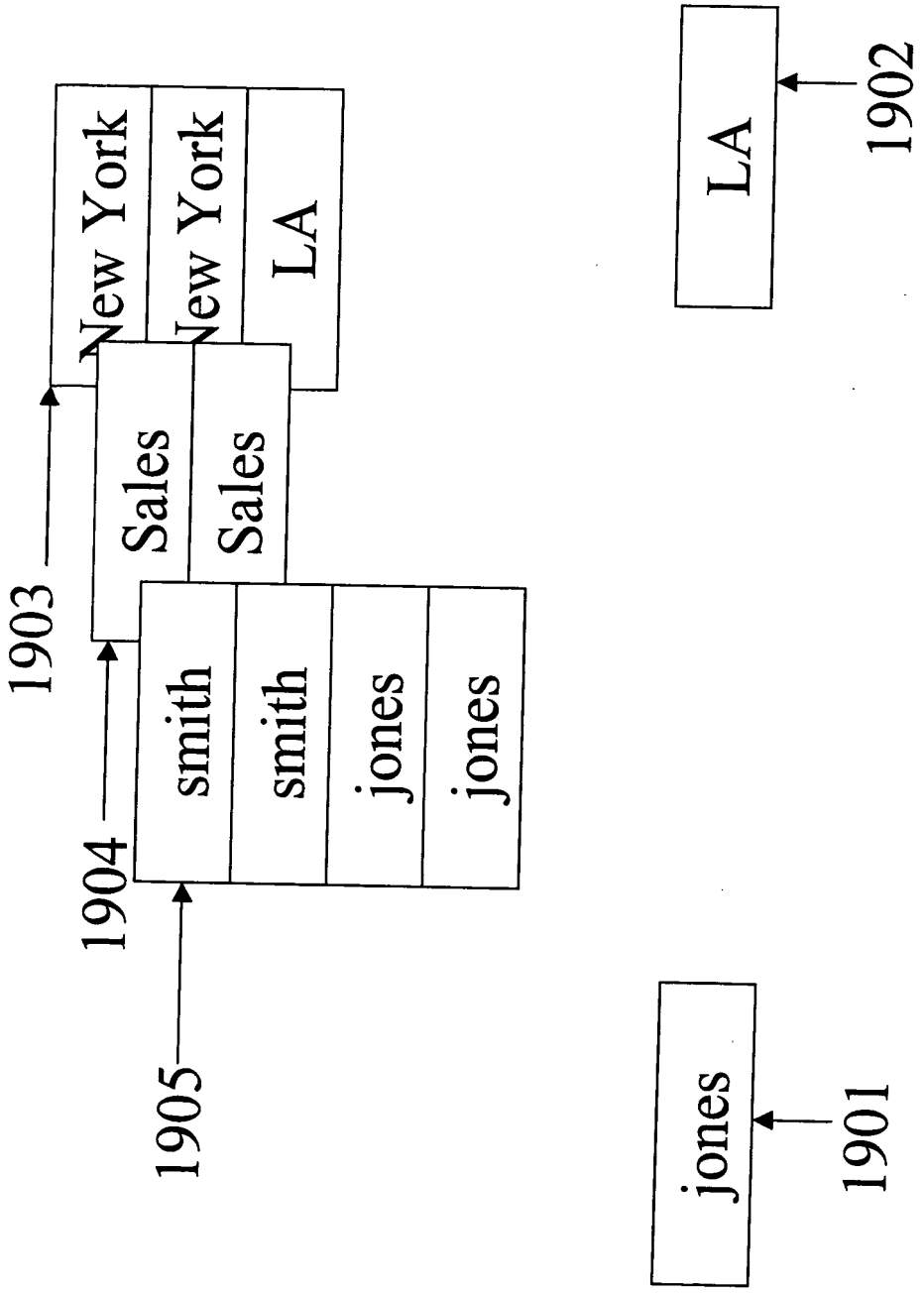

jones
1901
LA
1902
1903
New York
New York
LA
Sales
Sales
1904
smith
smith
jones
jones
1905

FIG. 19

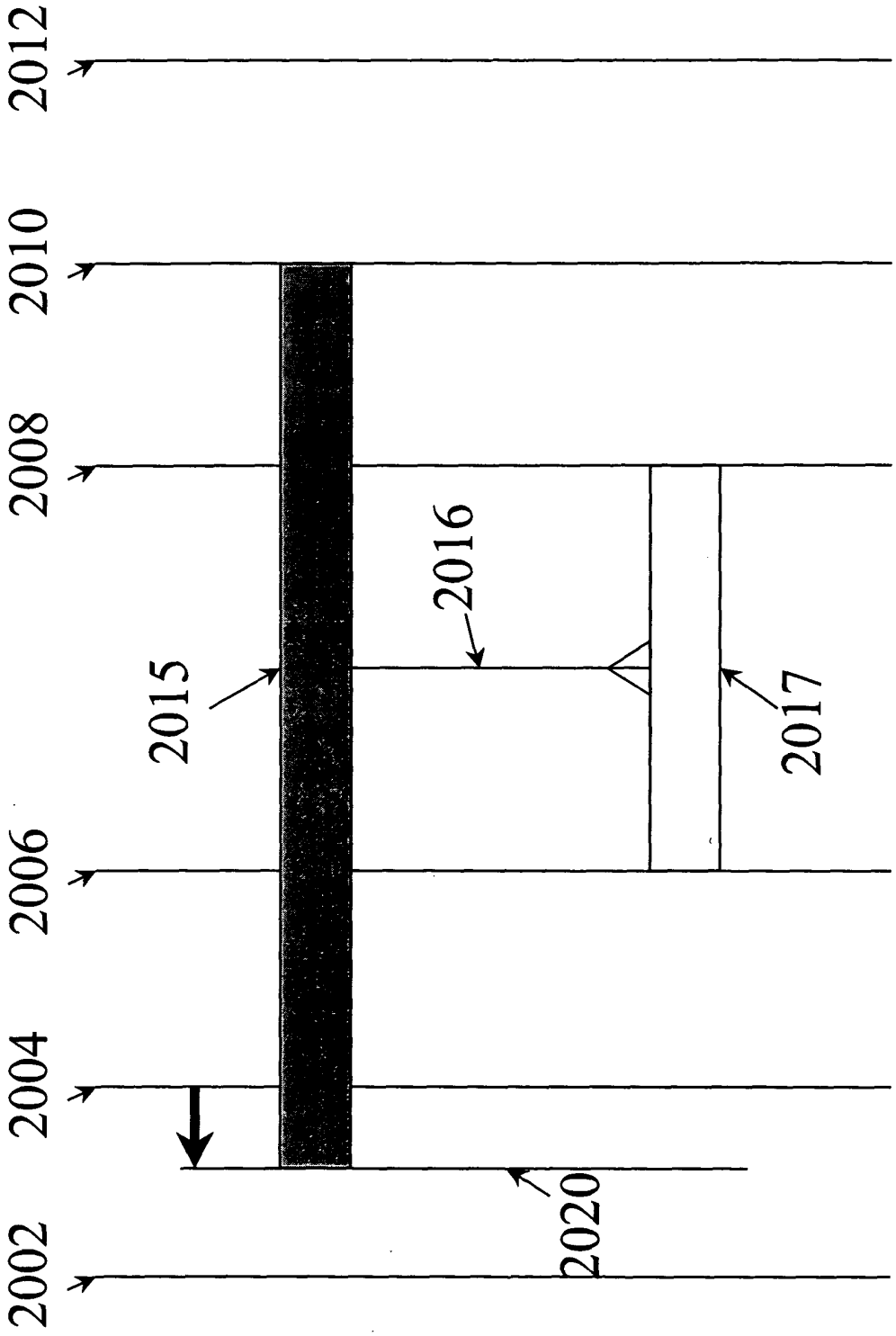


FIG. 20

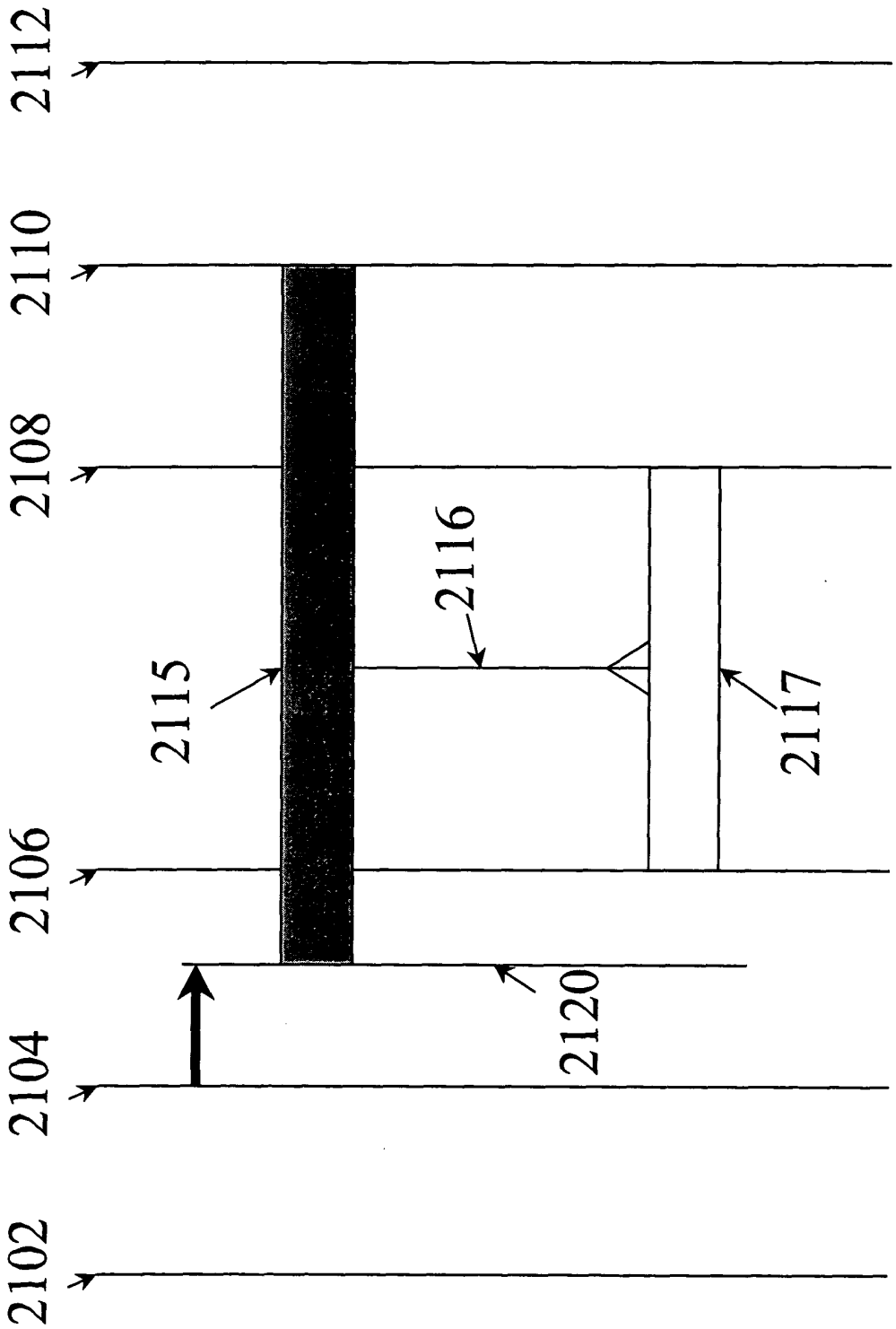


FIG. 21

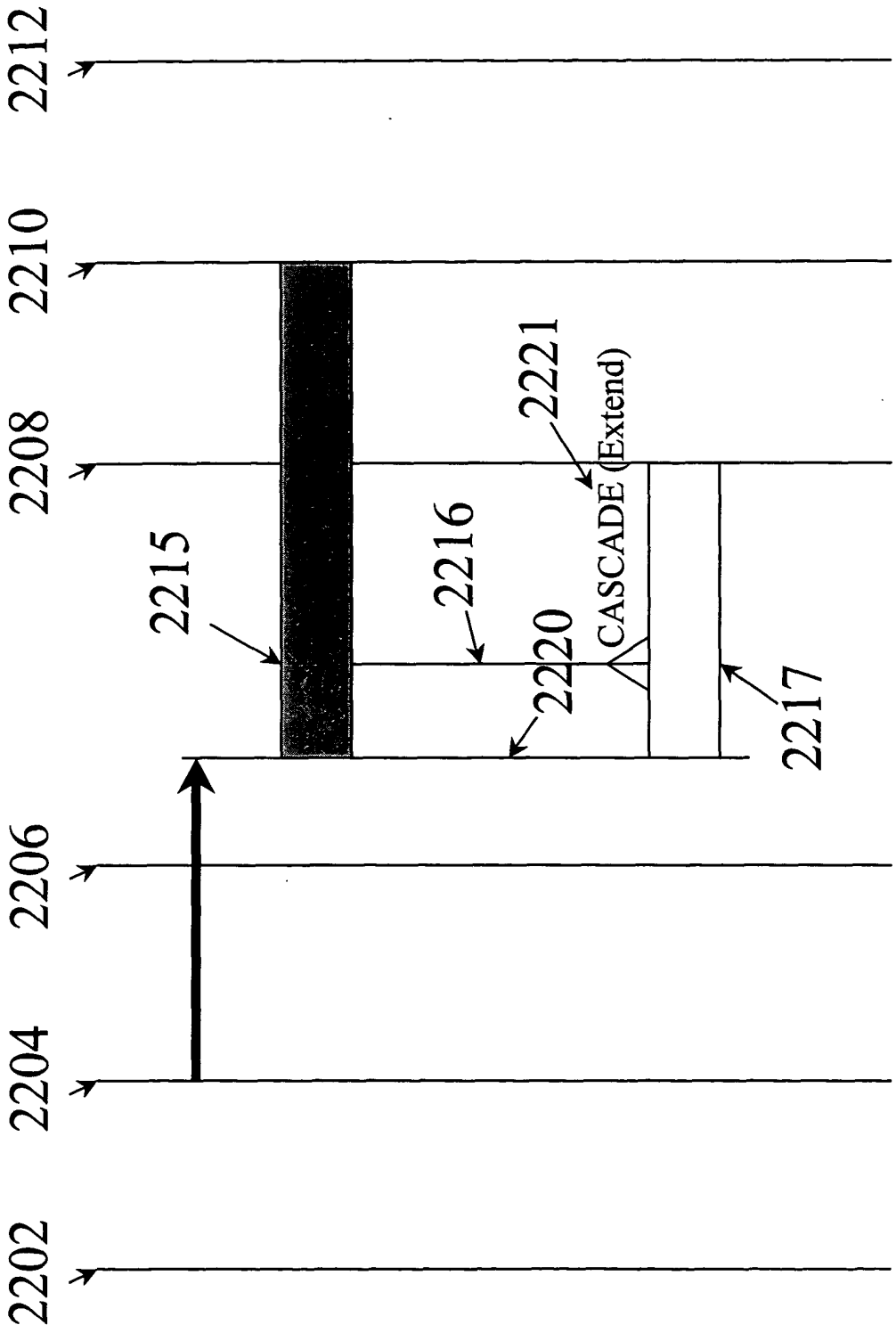

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
CASCADE (Extend)
2217

FIG. 22A

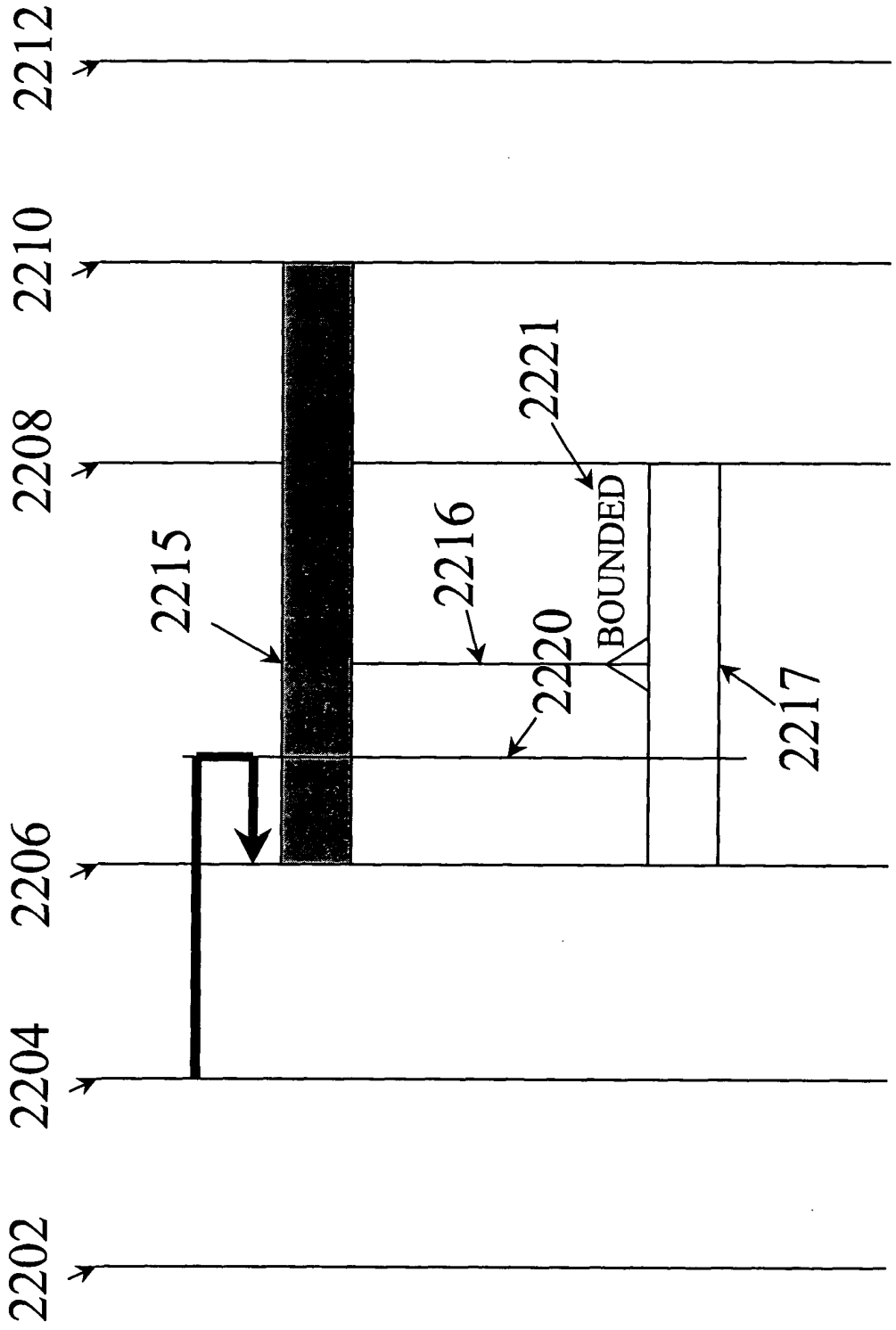

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
BOUNDED
2217

FIG. 22B

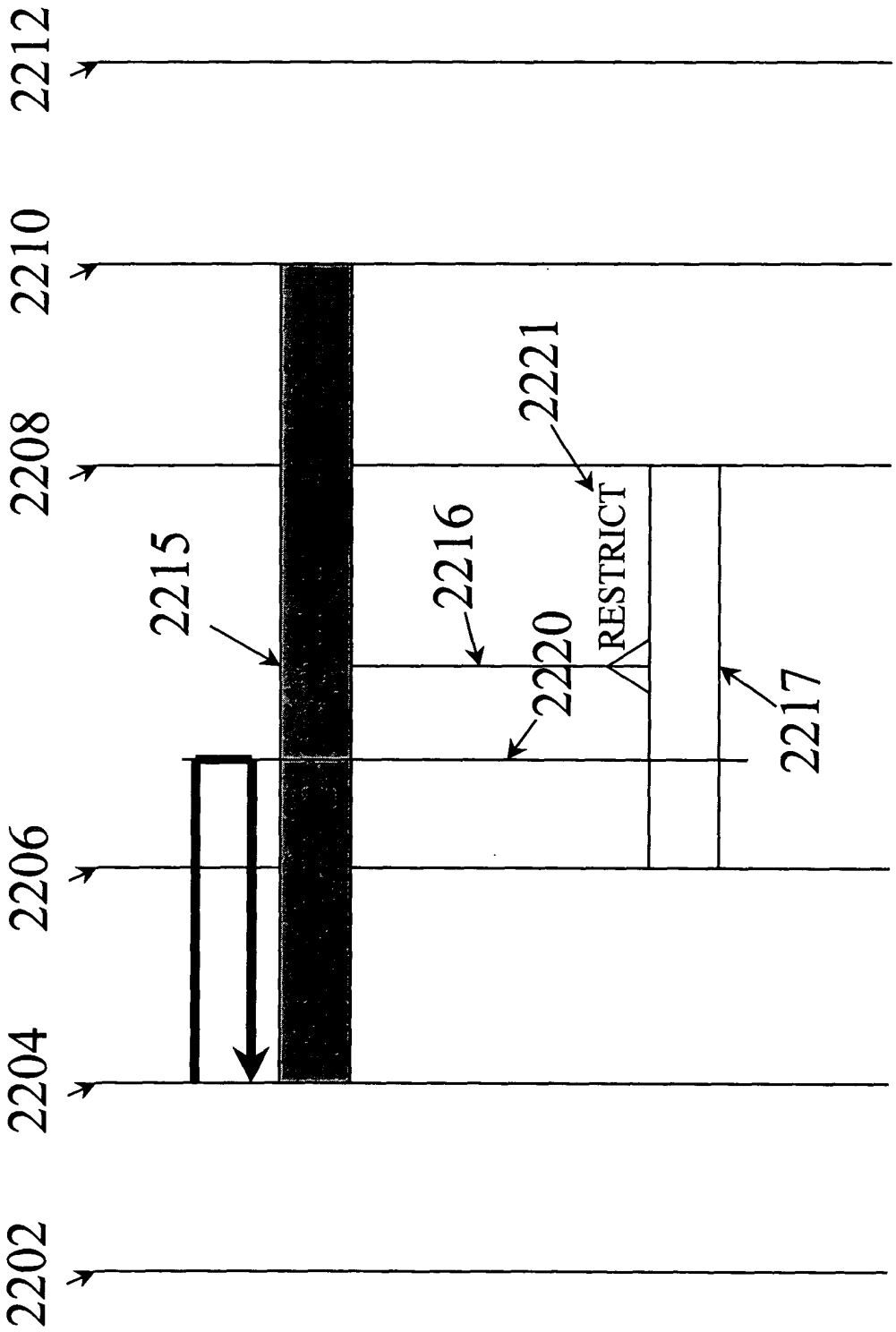

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
RESTRICT
2217

FIG. 22C

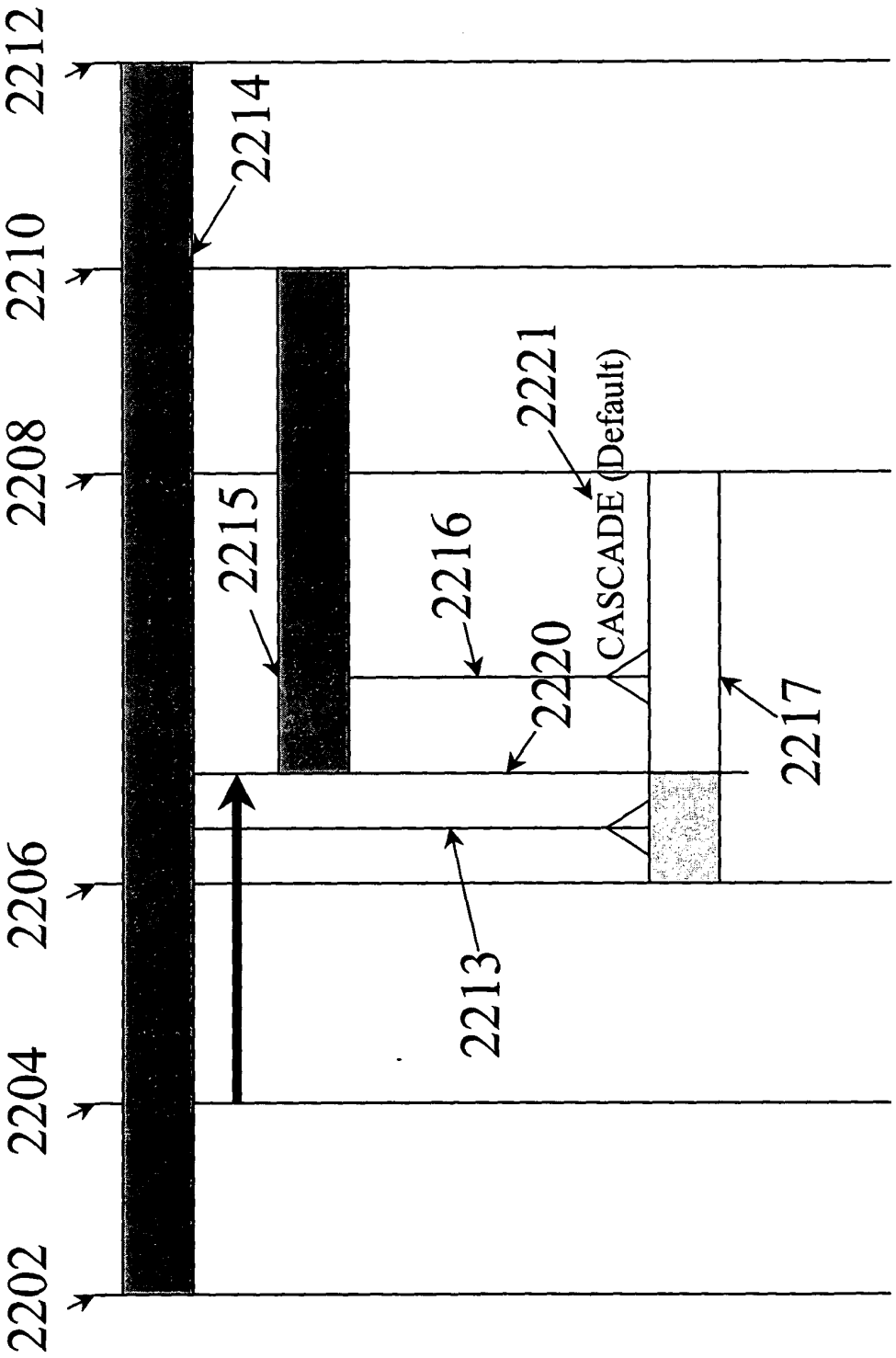

2202
2204
2206
2208
2210
2212
2214
2215
2216
2217
2220
2221
CASCADE (Default)
2213

FIG. 22D

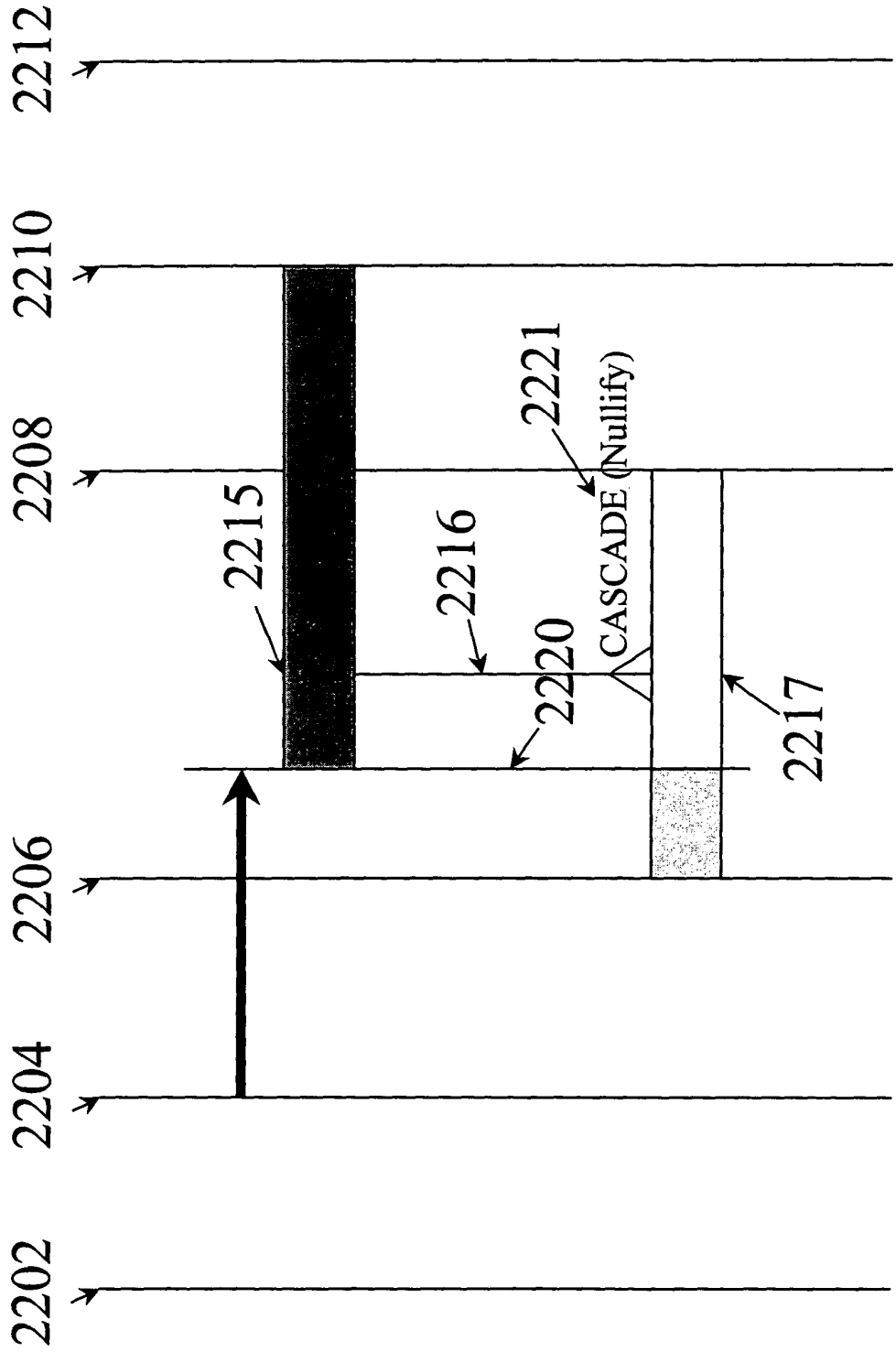

2212
2210
2208
2206
2204
2202
2215
2216
2220
2221
CASCADE (Nullify)
2217

FIG. 22E

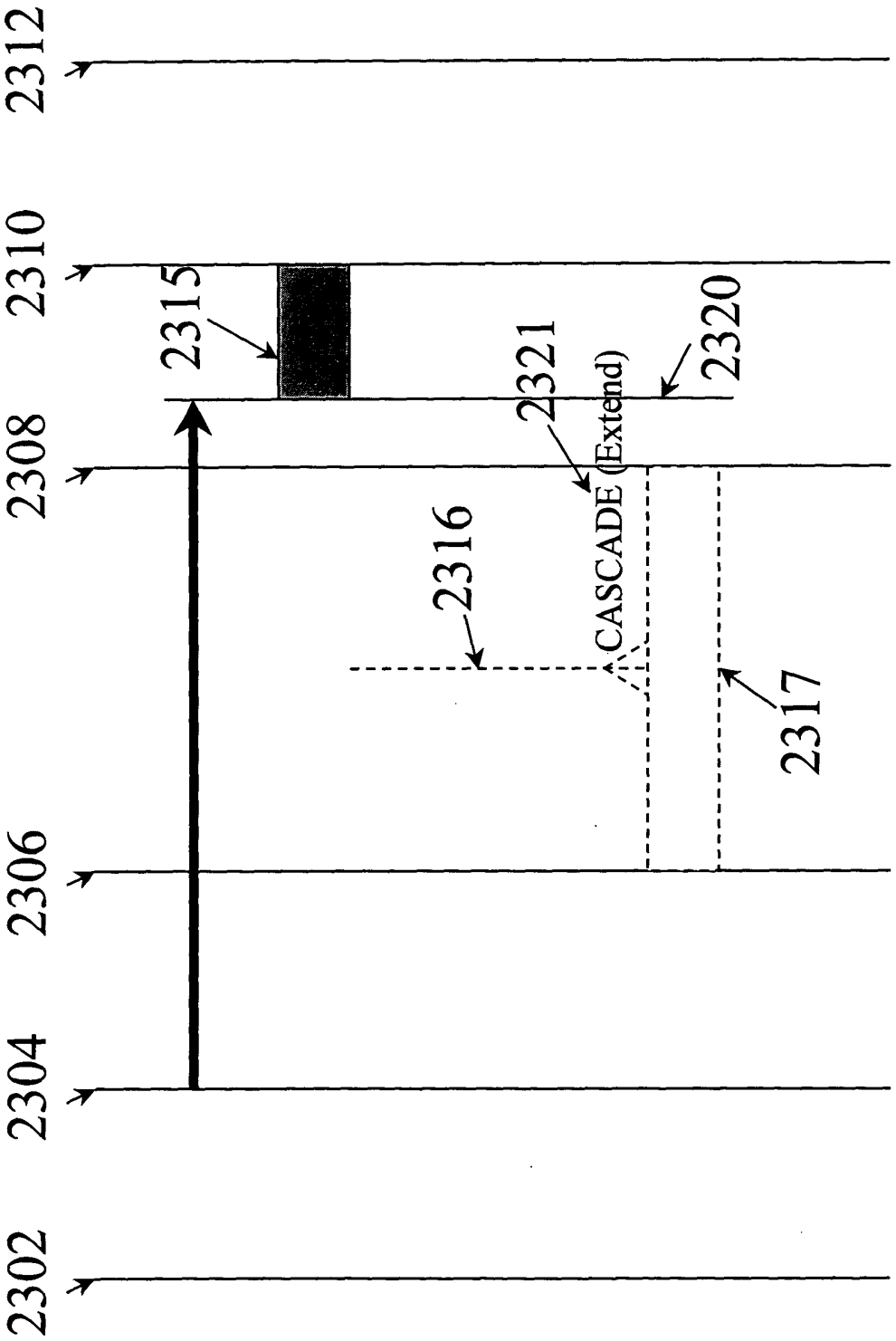

2312
2310
2308
2306
2304
2302
2315
2321
2320
2316
CASCADE (Extend)
2317

FIG. 23A

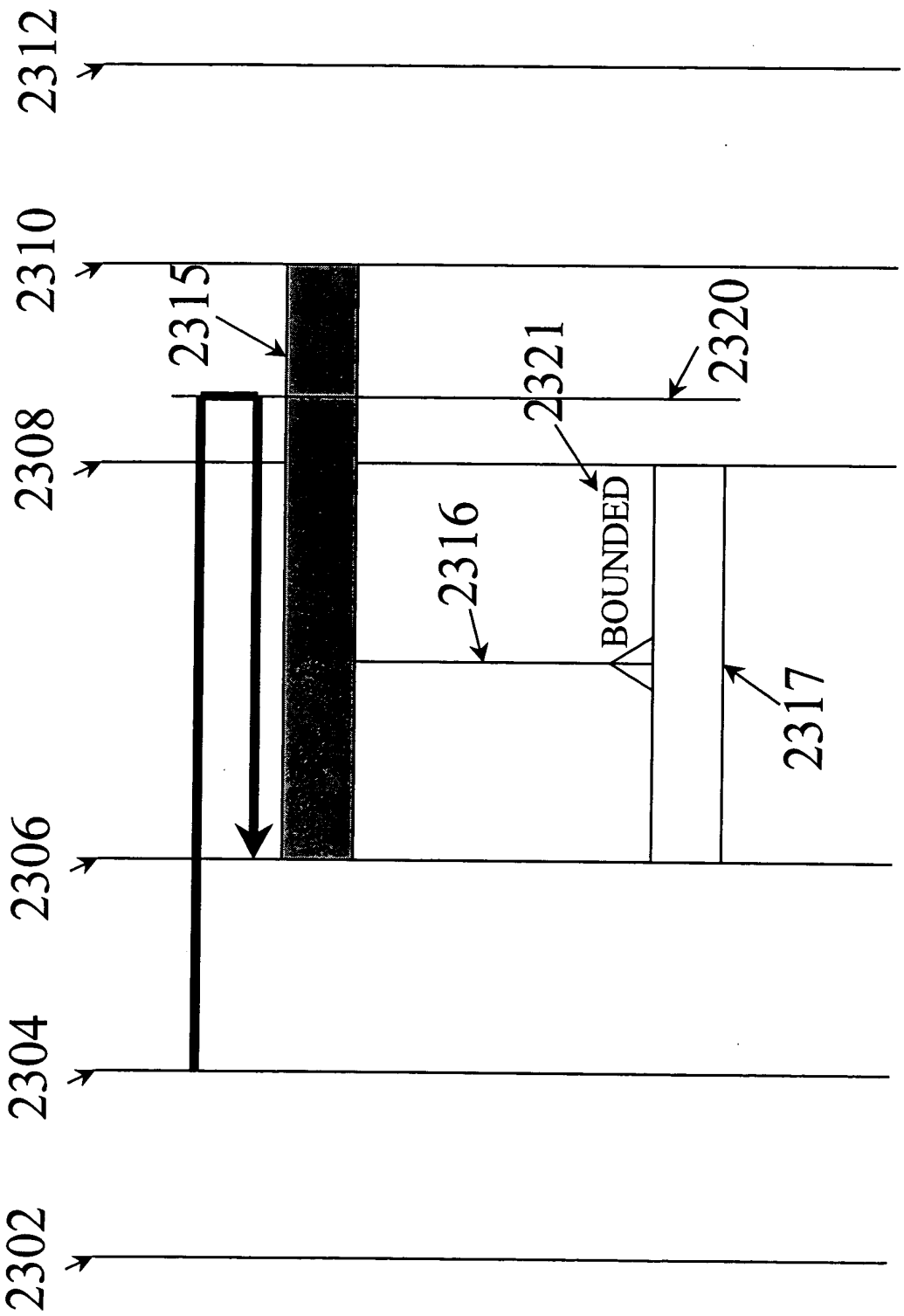

2312
2310
2308
2306
2304
2302
2315
2321
2320
2316
BOUNDED
2317

FIG. 23B

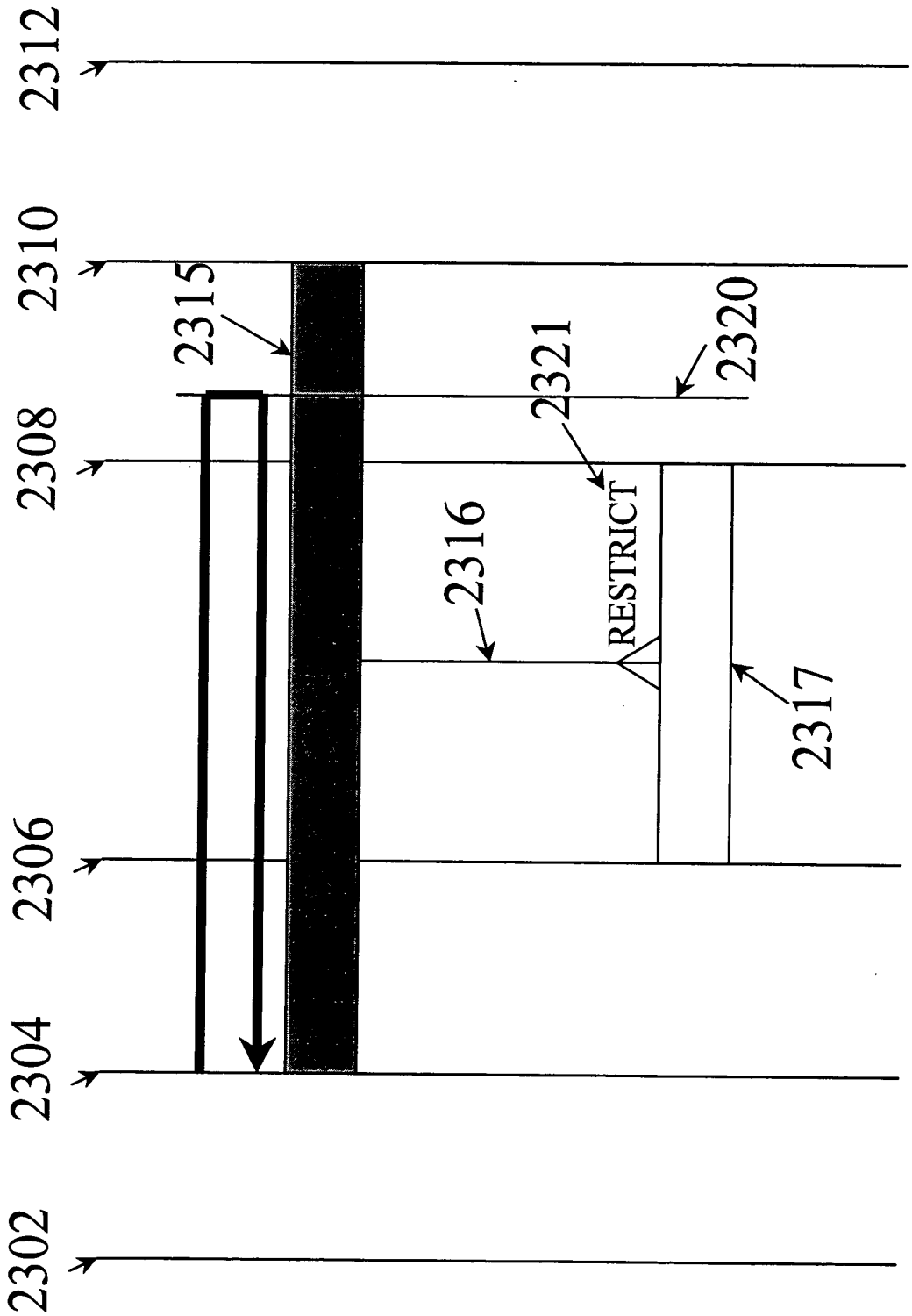

2312
2310
2315
2320
2321
2308
2316
RESTRICT
2306
2317
2304
2302

FIG. 23C

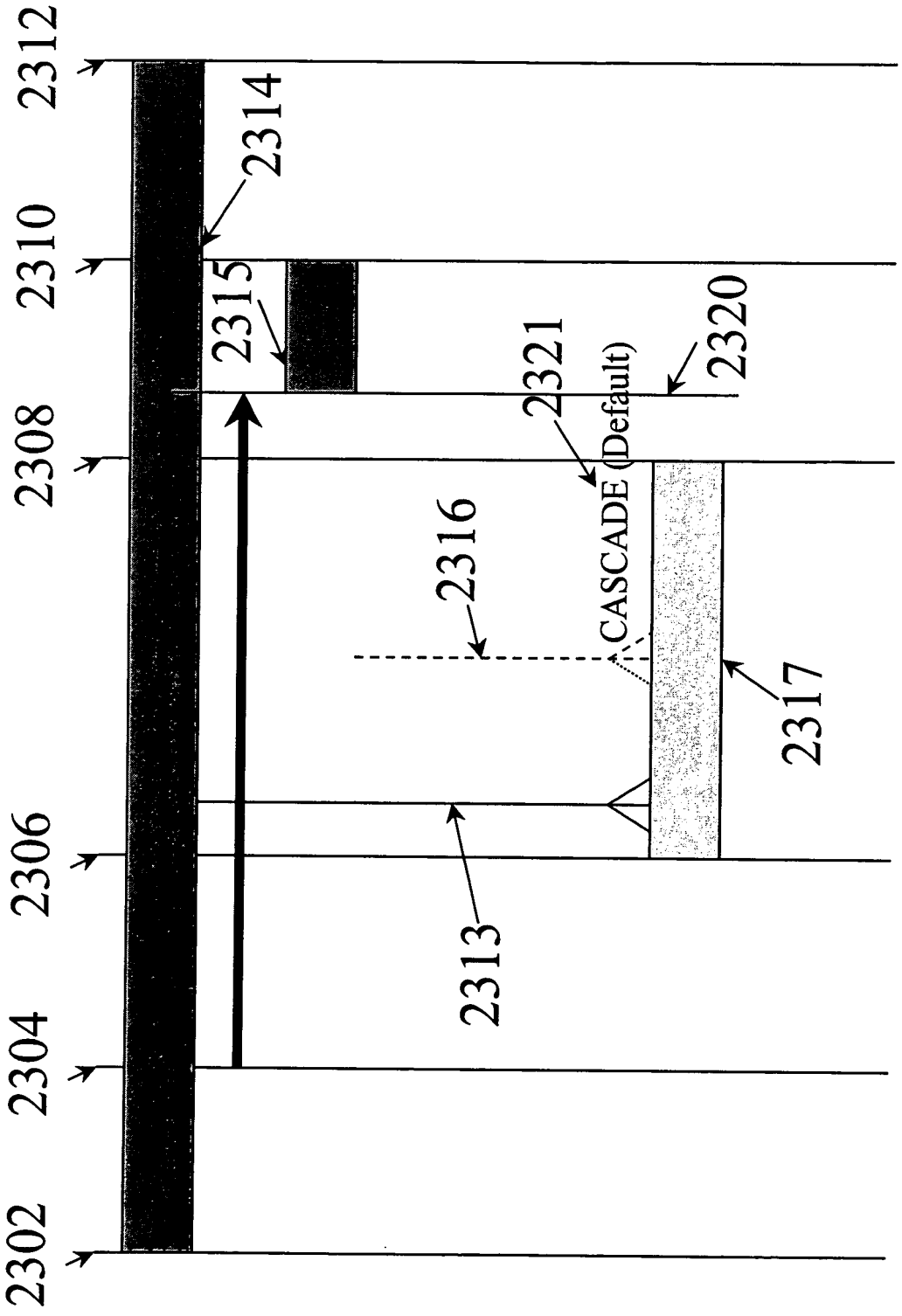

2312
2314
2310
2315
2321
2320
2308
CASCADE (Default)
2316
2317
2306
2313
2304
2302

FIG. 23D

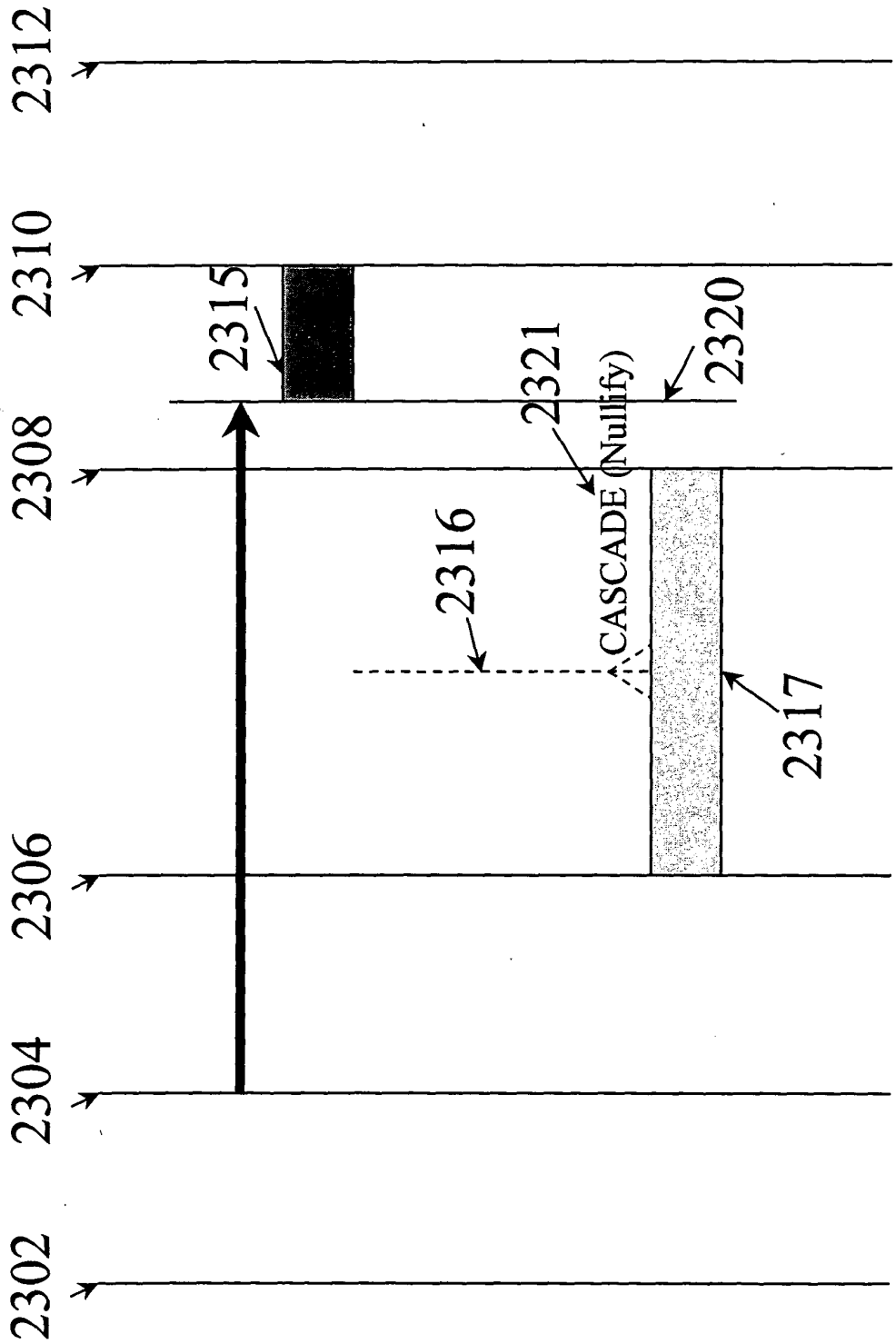

2312
2310
2308
2306
2304
2302
2315
2321
2320
2316
CASCADE (Nullify)
2317

FIG. 23E

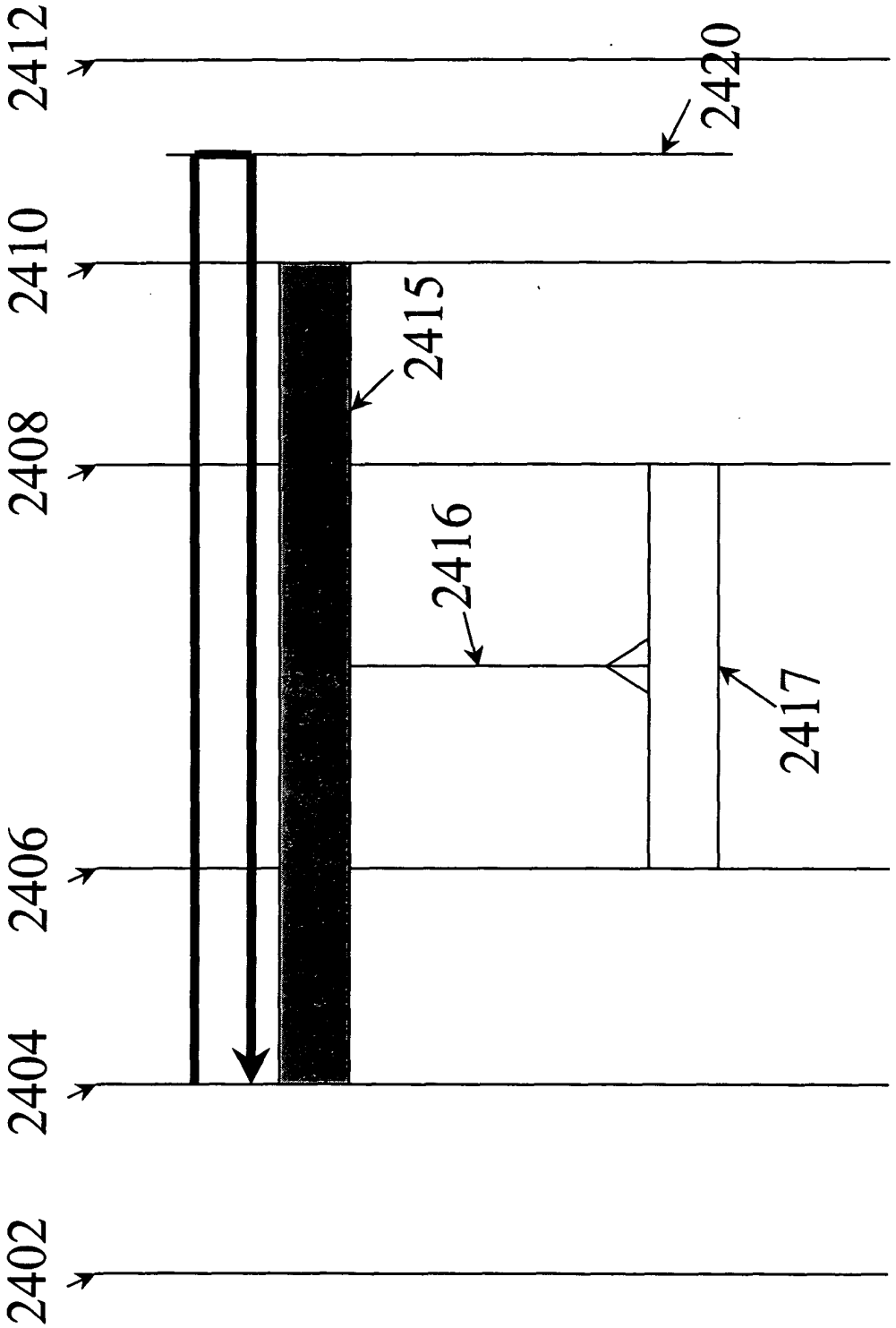


FIG. 24

Action	Rule	This Invention	Prior Art
Insert	cascade (extend)	yes	no equivalent
	bounded	yes	no equivalent
	restrict	yes	no equivalent
	cascade (default)	yes	no equivalent
	cascade (nullify)	yes	no equivalent
Alter Insert Back	cascade (extend)	yes	no equivalent
	bounded	yes	no equivalent
	restrict	yes	no equivalent
	cascade (default)	yes	no equivalent
	cascade (nullify)	yes	no equivalent
Alter Insert Forward	cascade (extend)	yes	no equivalent
	bounded	yes	no equivalent
	restrict	yes	no equivalent
	cascade (default)	yes	no equivalent
	cascade (nullify)	yes	no equivalent
Update	cascade (extend)	yes	no
	bounded	yes	no equivalent
	restrict	yes	part (via server side code)
	cascade (default)	yes	no
	cascade (nullify)	yes	no
Delete	cascade (extend)	yes	yes
	bounded	yes	no equivalent
	restrict	yes	yes
	cascade (default)	yes	no
	cascade (nullify)	yes	no
Alter Delete Back	cascade (extend)	yes	no equivalent
	bounded	yes	no equivalent
	restrict	yes	no equivalent
	cascade (default)	yes	no equivalent
	cascade (nullify)	yes	no equivalent
Alter Delete Forward	cascade (extend)	yes	no equivalent
	bounded	yes	no equivalent
	restrict	yes	no equivalent
	cascade (default)	yes	no equivalent
	cascade (nullify)	yes	no equivalent

FIG. 25

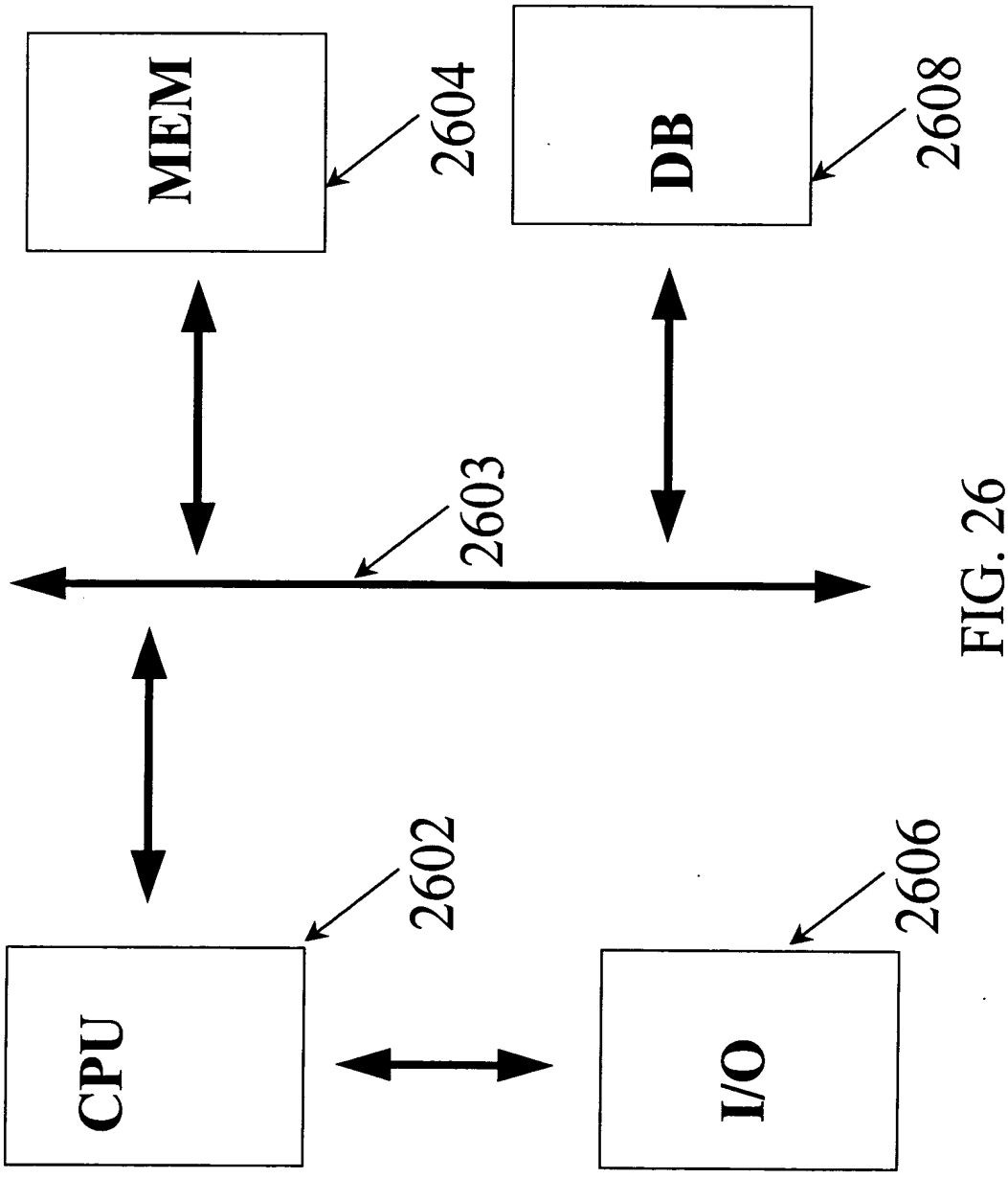


FIG. 26

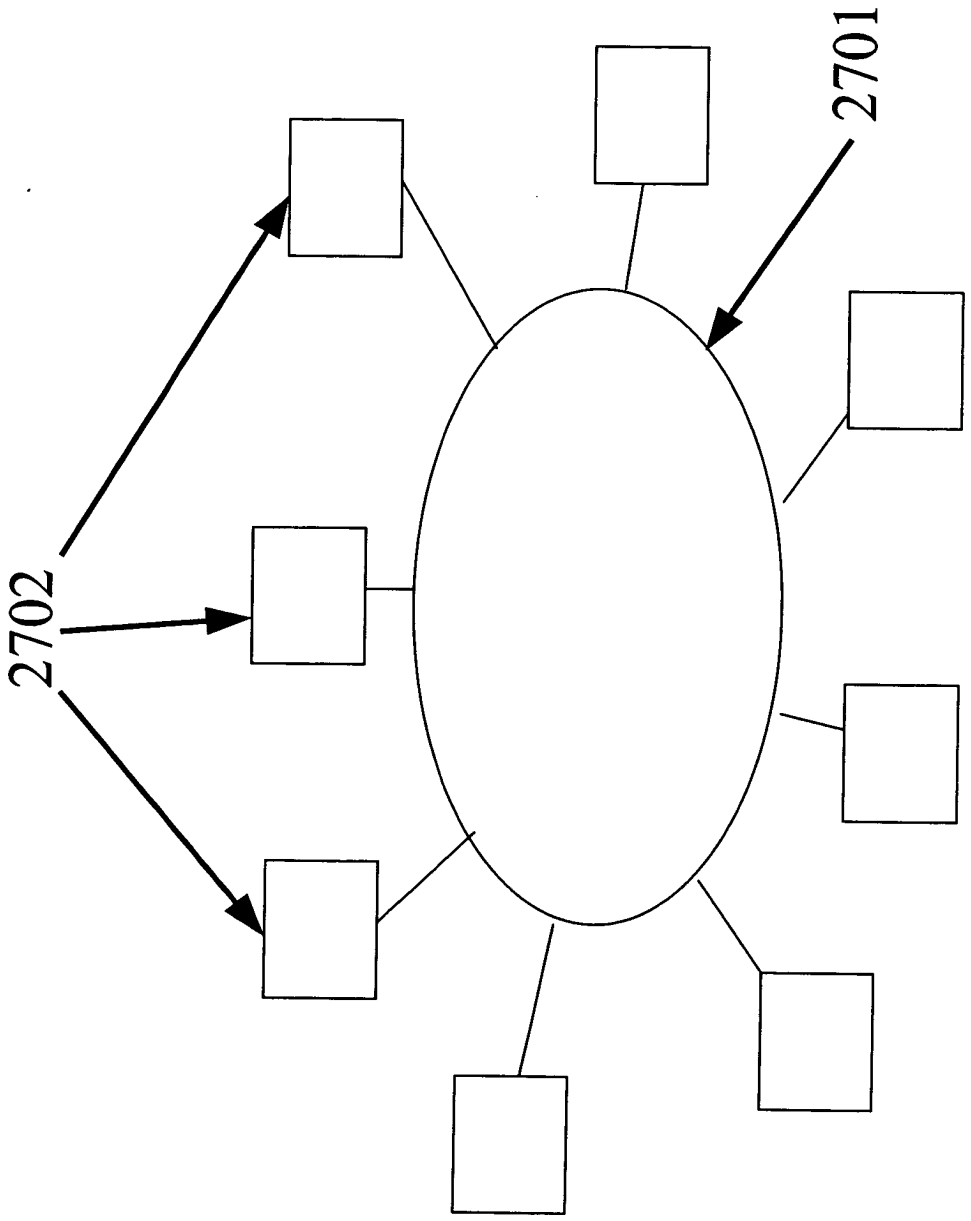


FIG. 27

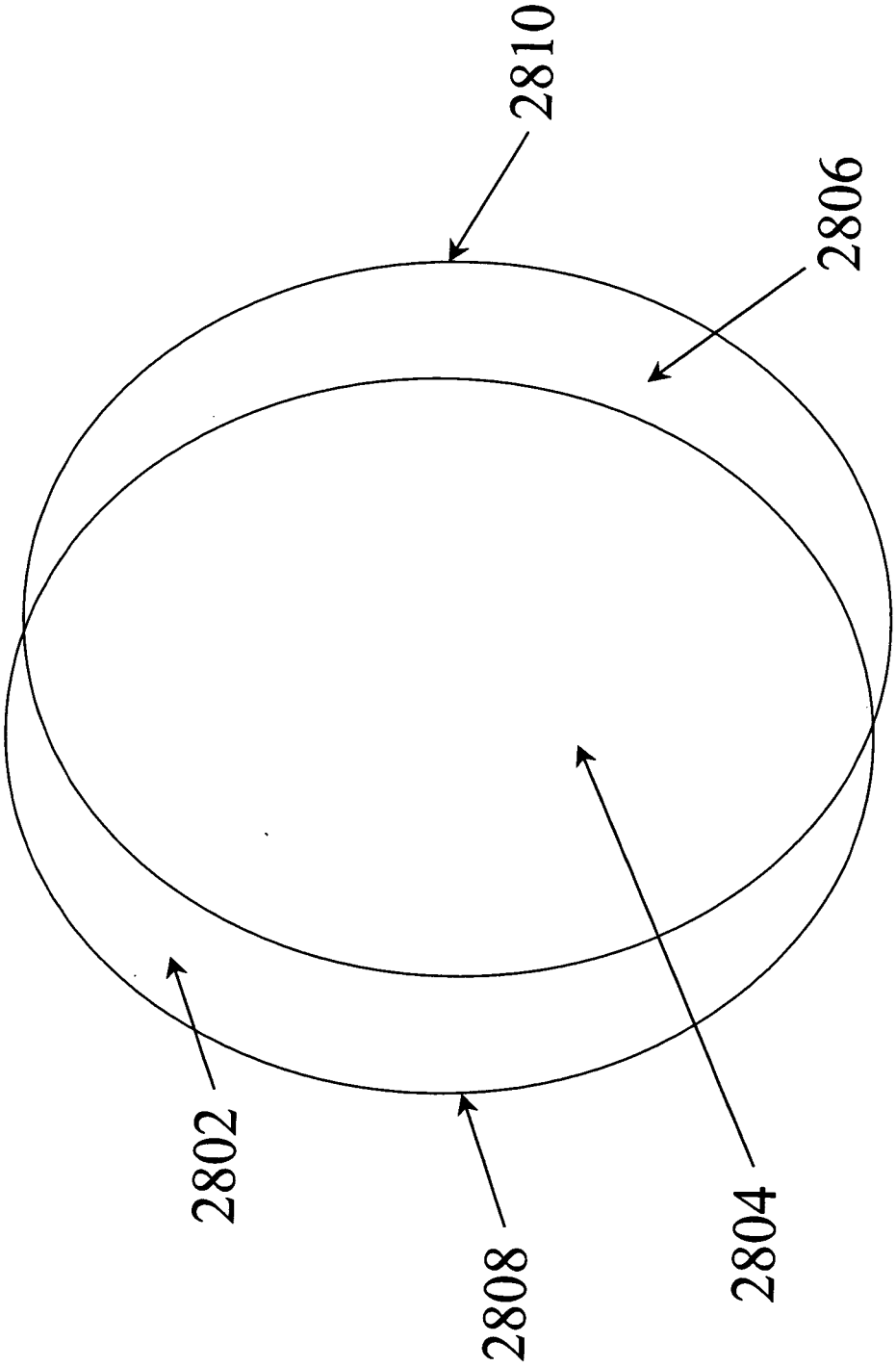


FIG. 28

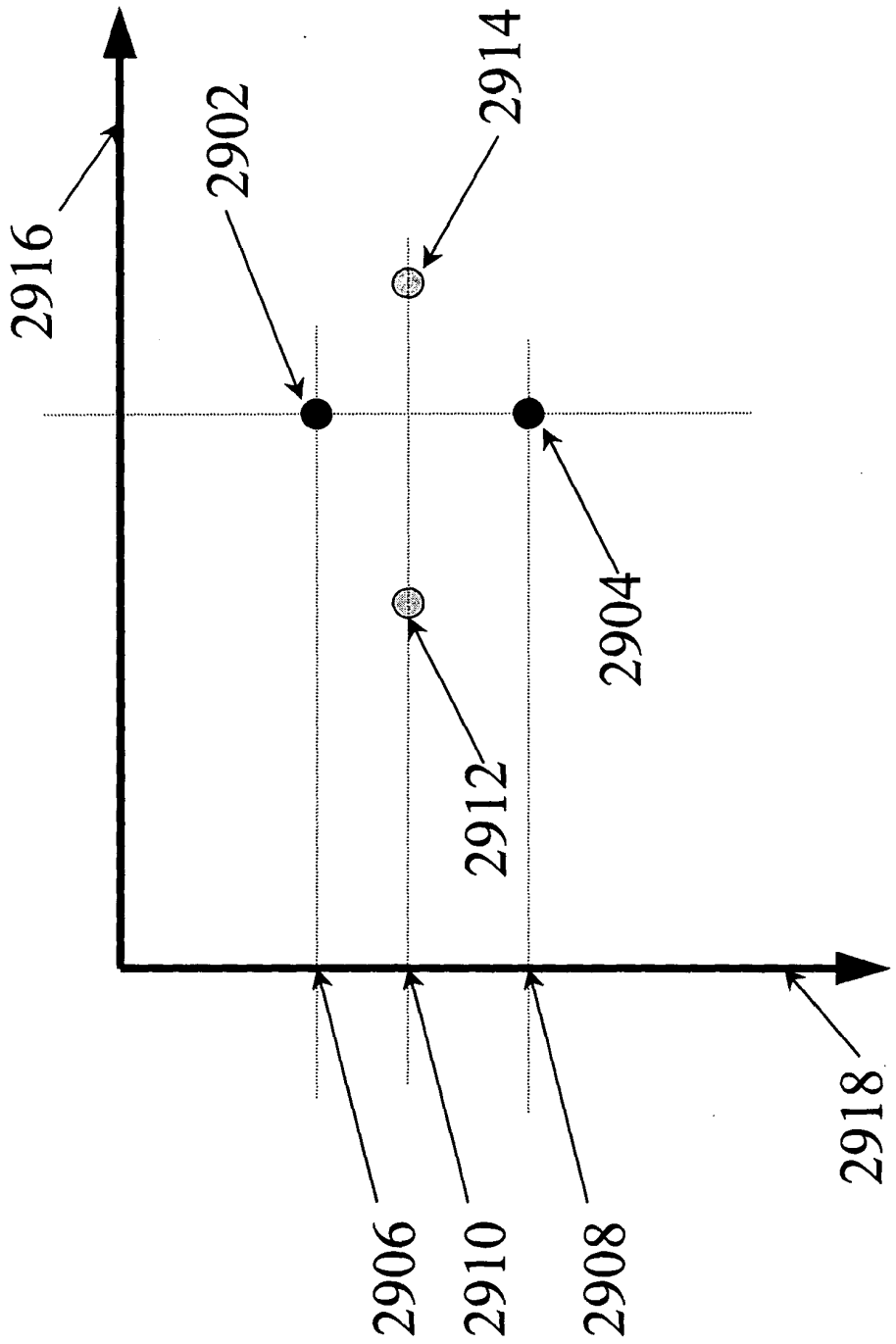


FIG. 29

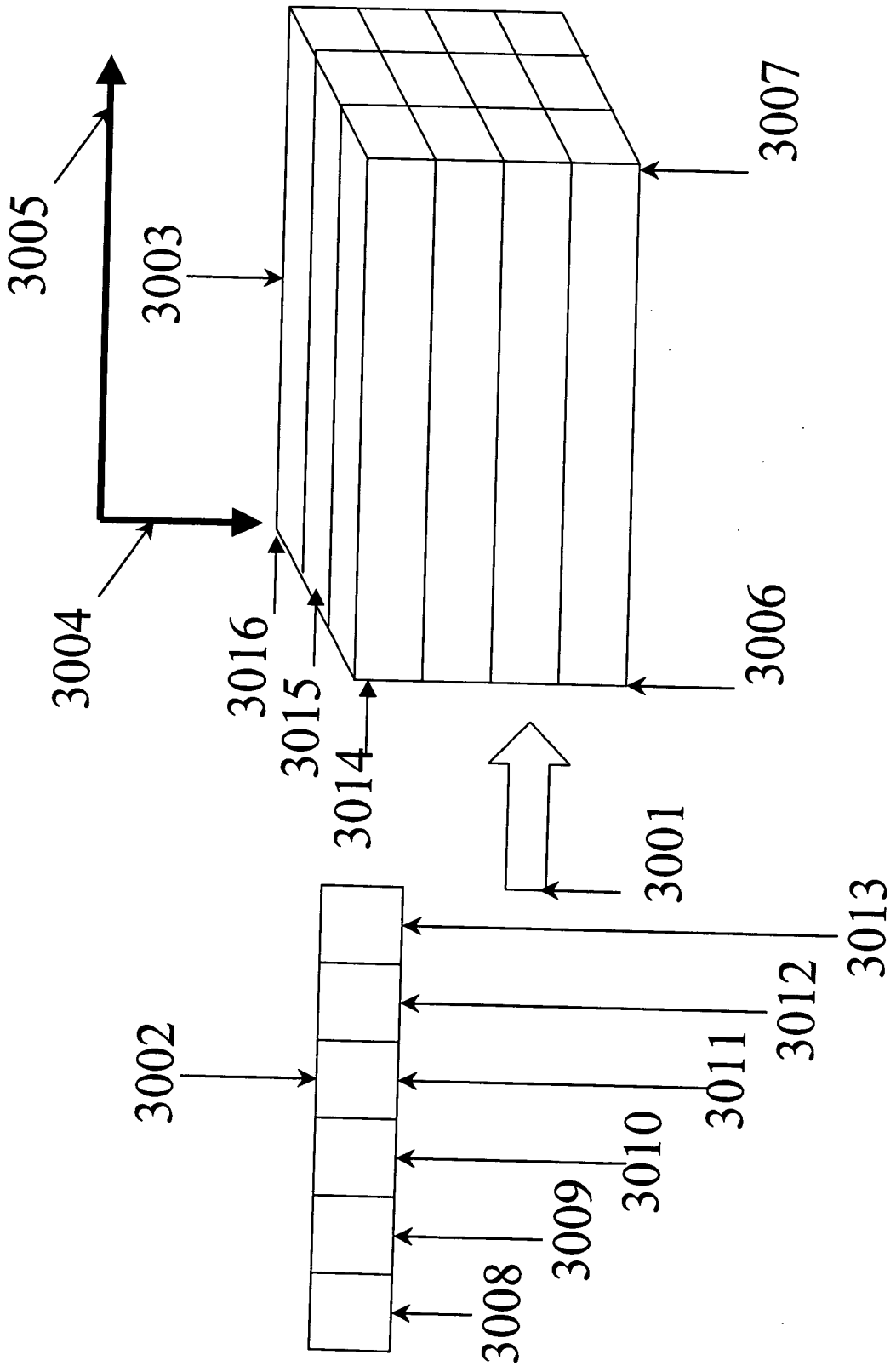

3005
3003
3007
3004
3016
3015
3014
3006
3001
3013
3012
3002
3011
3010
3009
3008

FIG. 30

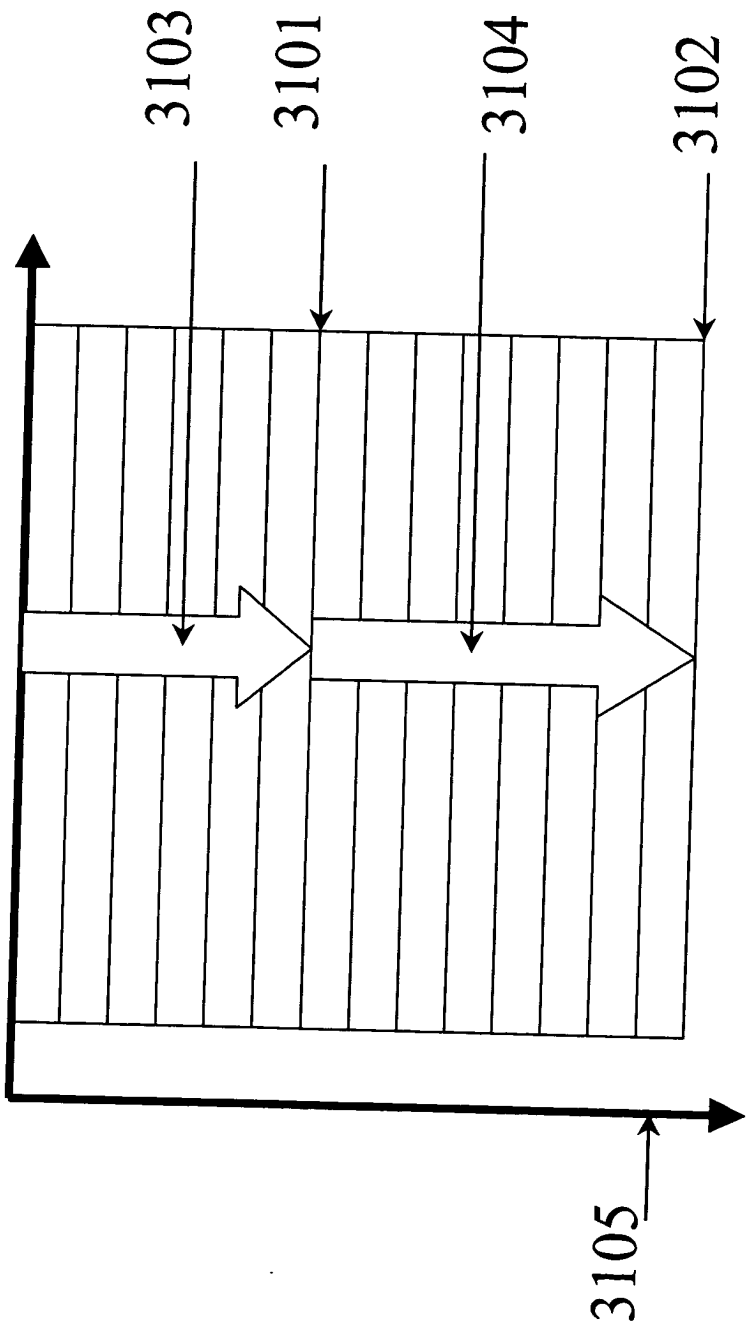


FIG. 31

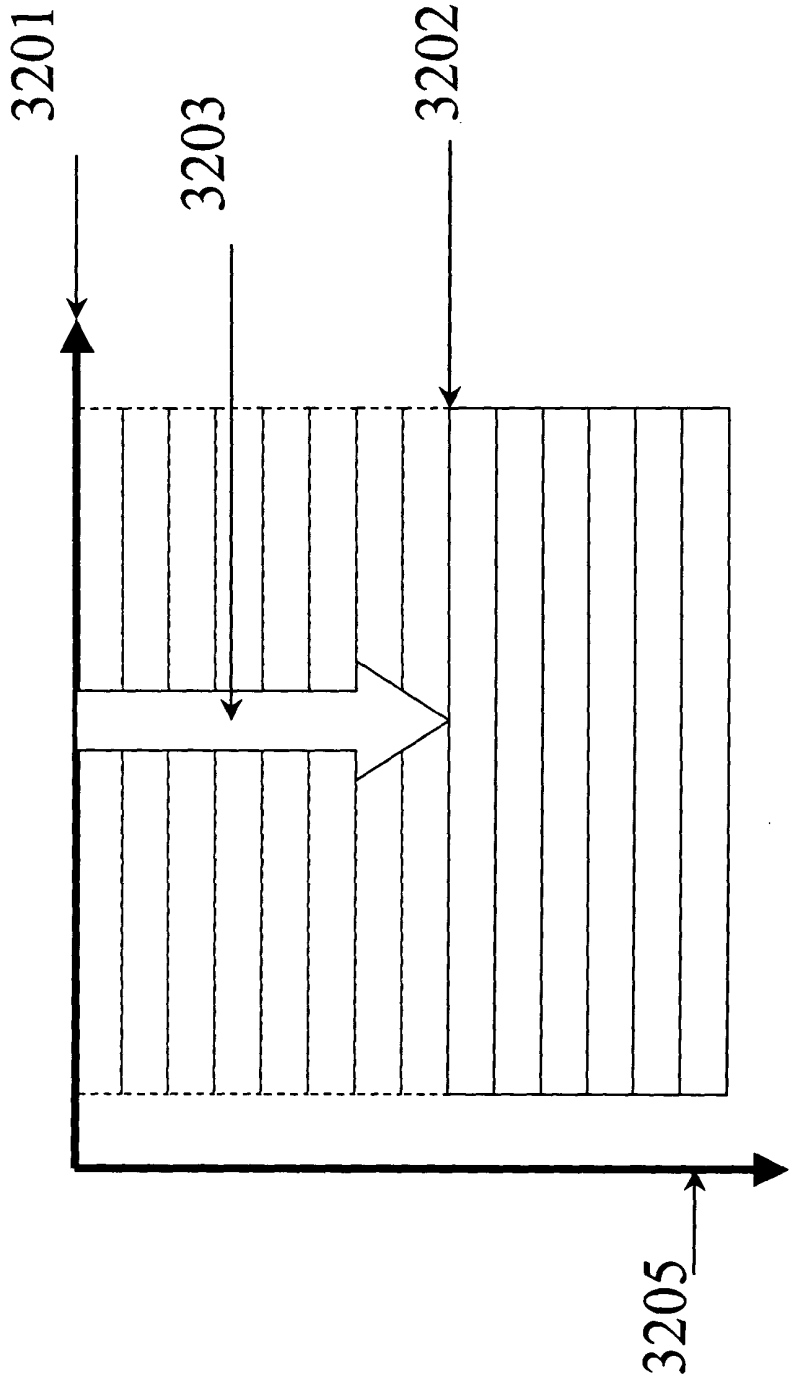


FIG. 32

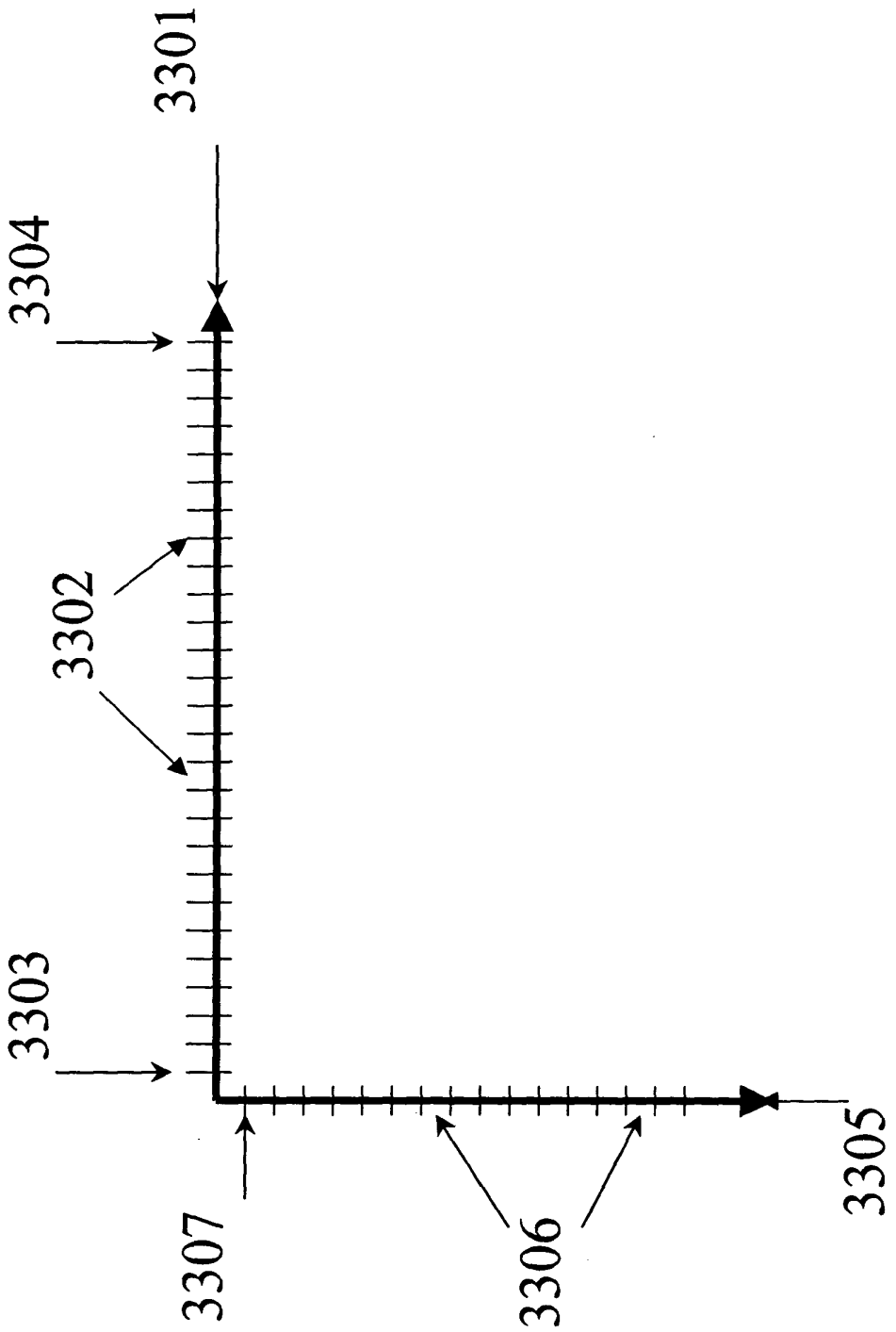


FIG. 33

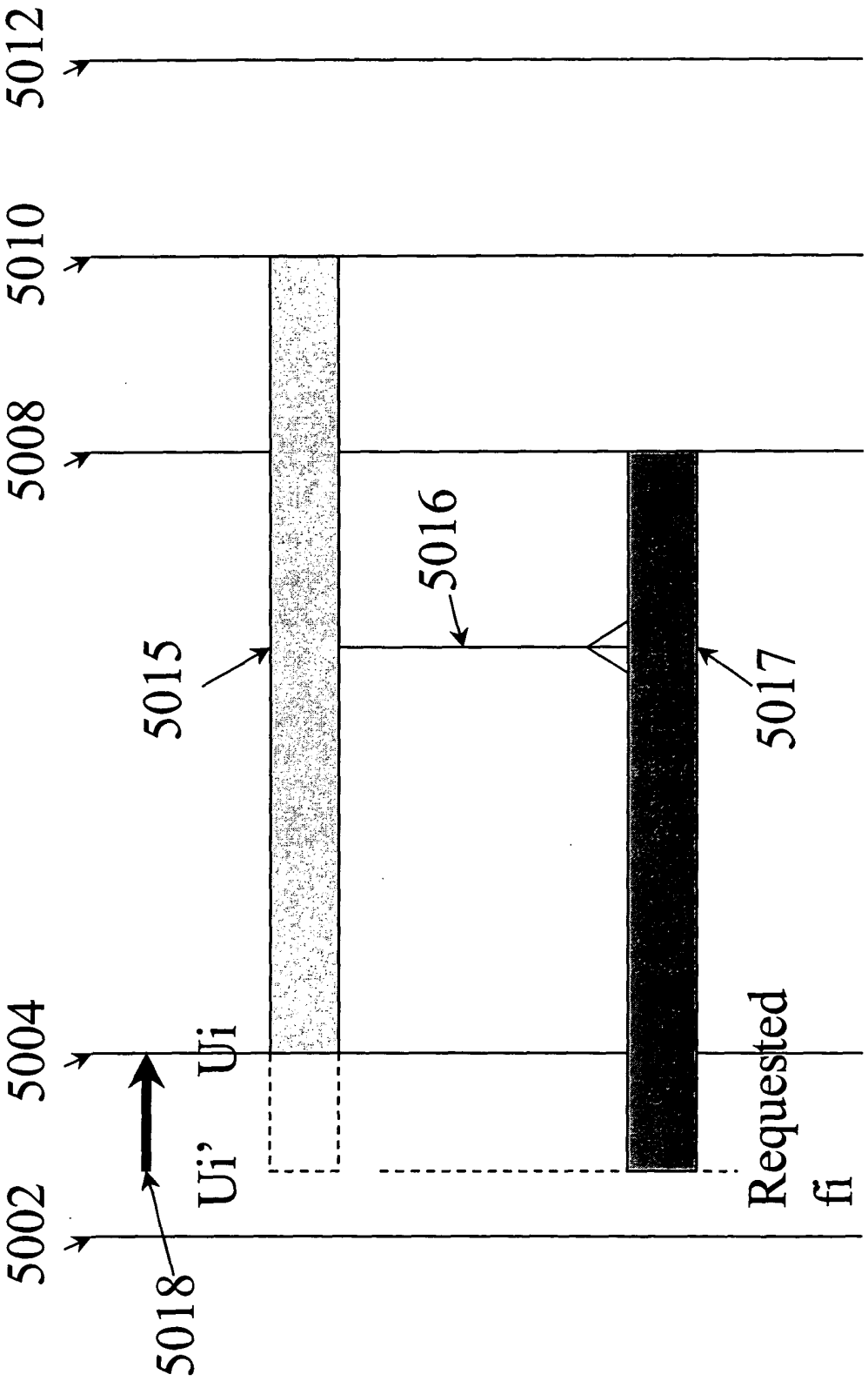

5012
5010
5008
5004
5002
5018
Ui'
Ui
5015
5016
5017
Requested
fi

FIG. 50

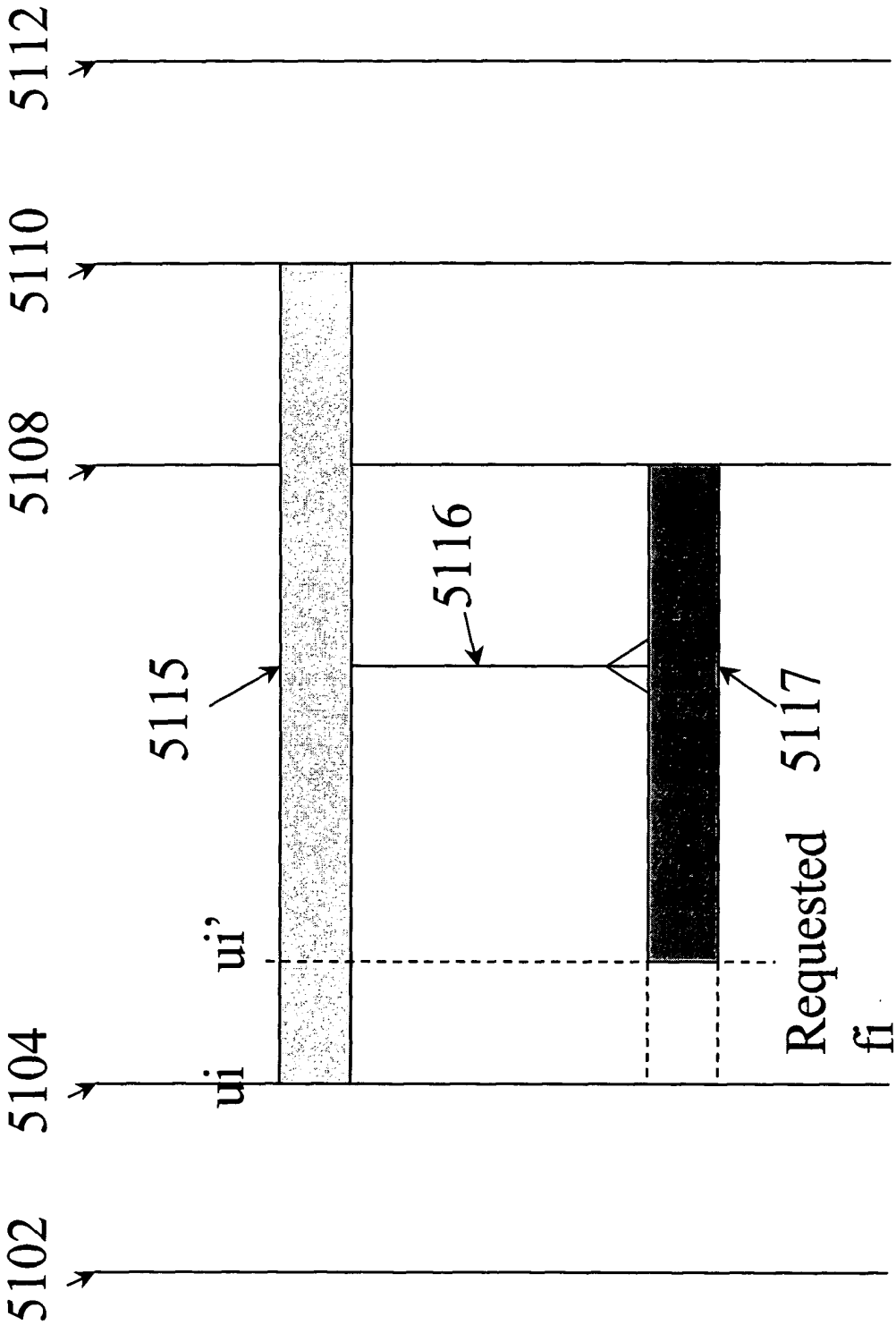


FIG. 51

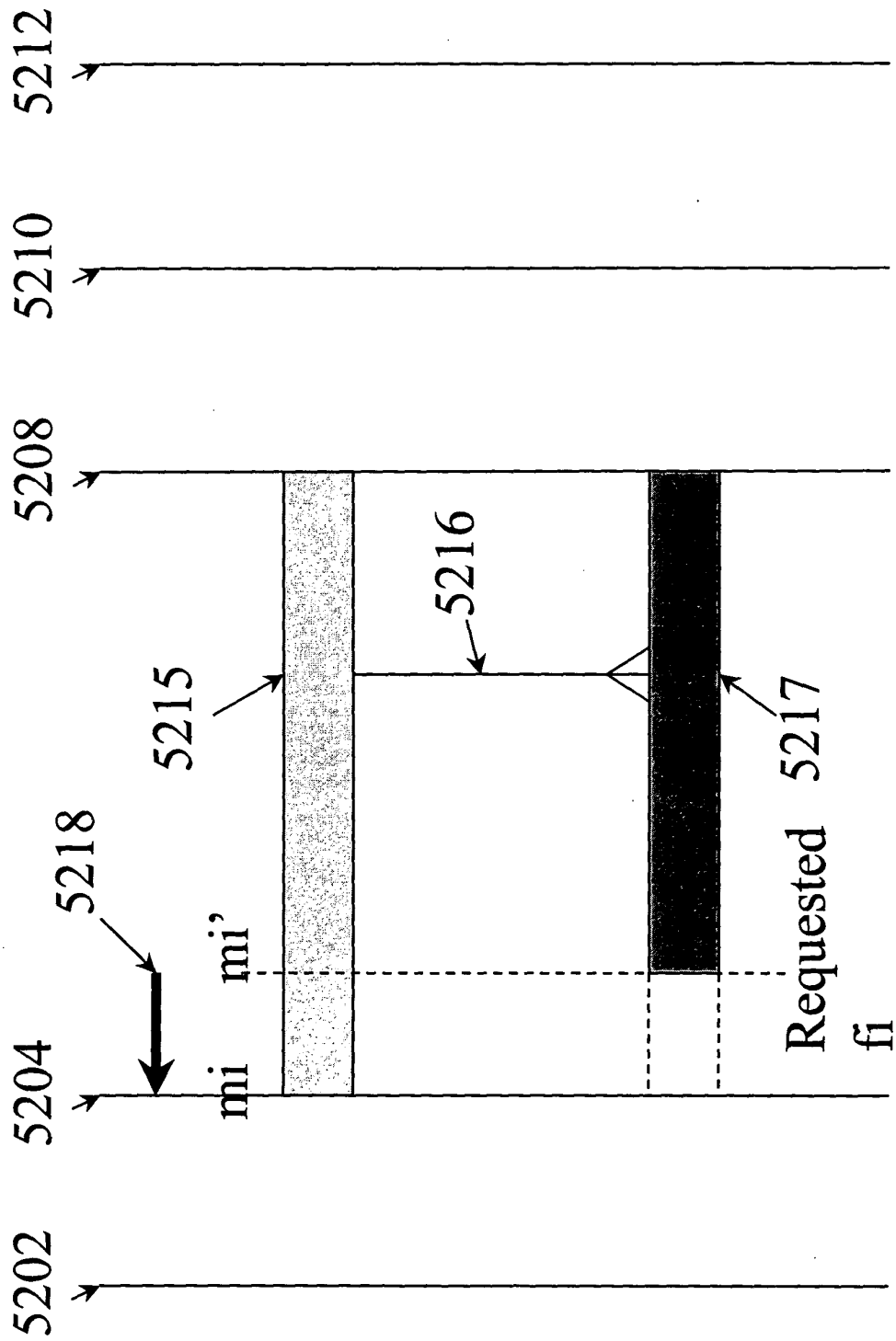

5212
5210
5208
5216
5215
5217
5218
mi'
mi
5204
Requested
fi
5202

FIG. 52

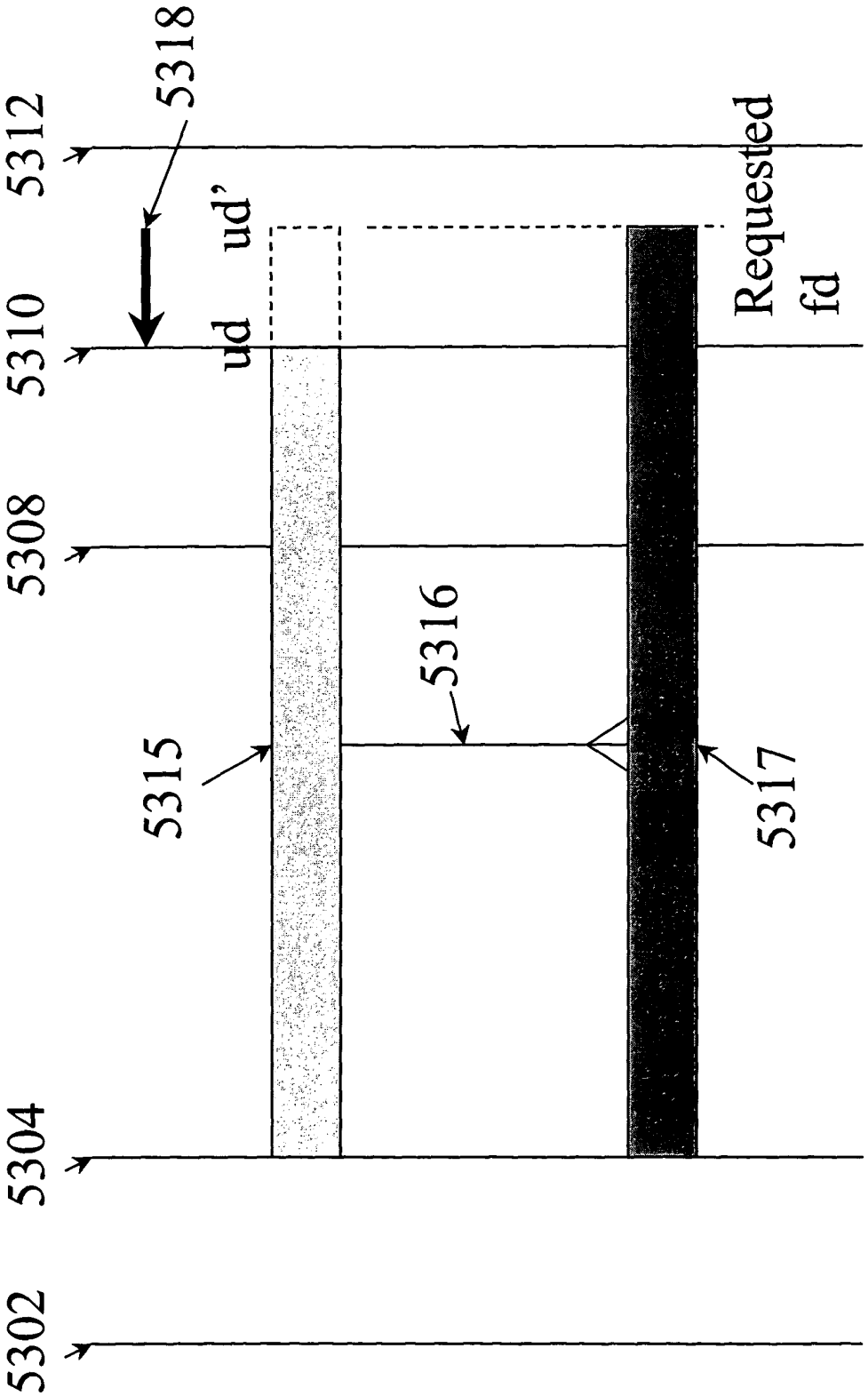

5318
5312
5310
5308
5304
5302
ud
ud'
Requested
fd
5315
5316
5317

FIG. 53

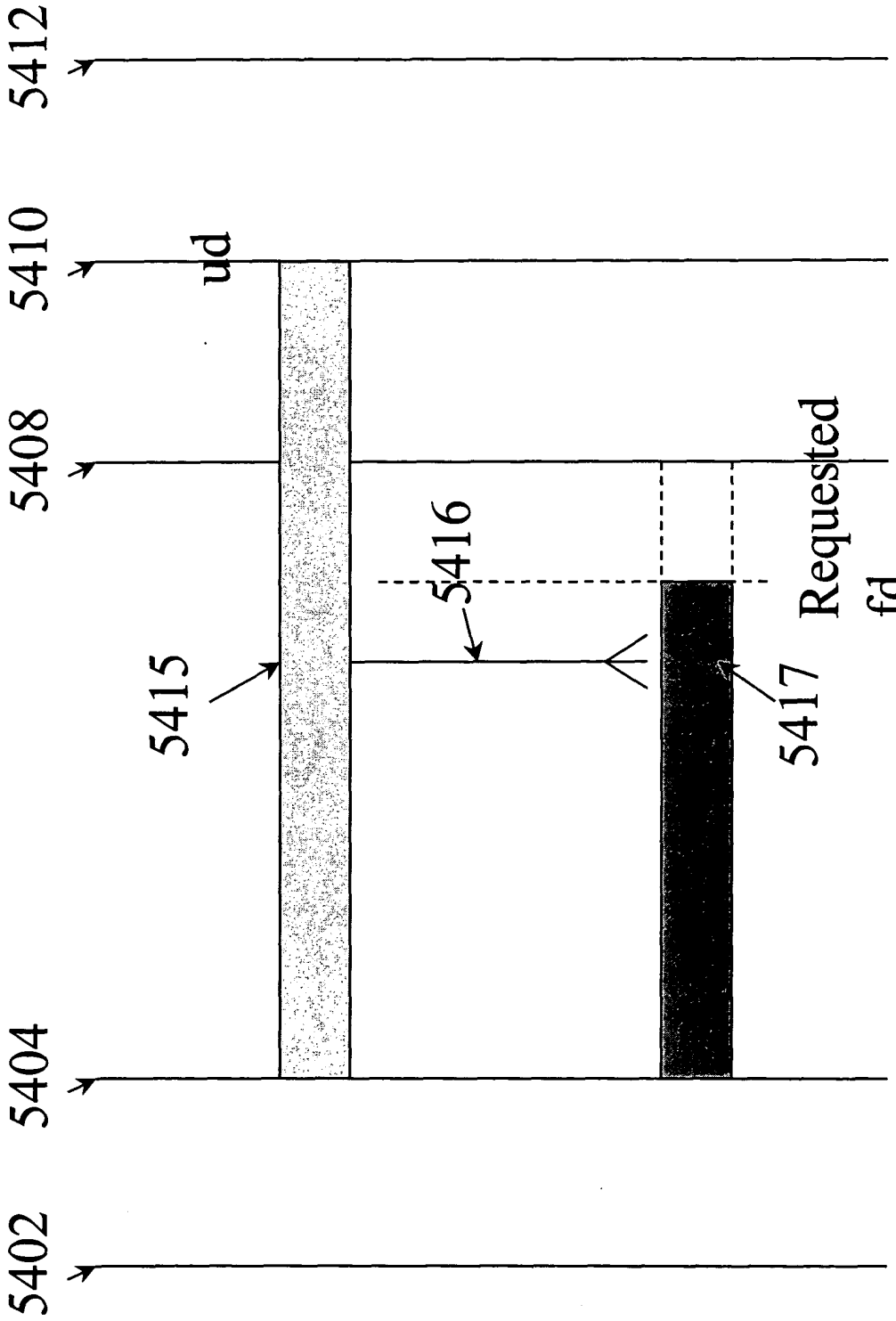


FIG. 54

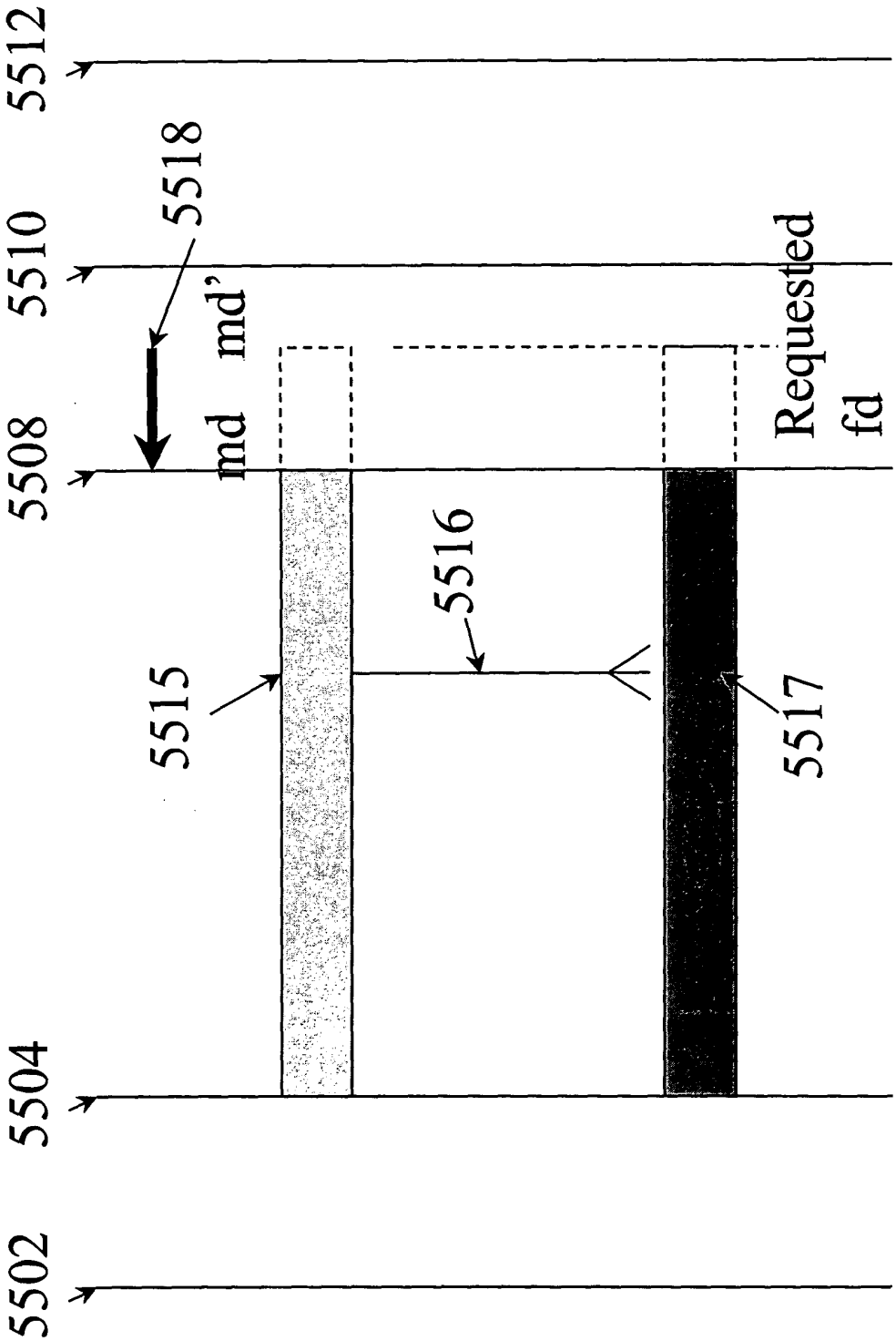

5512
5510
5508
5504
5502
5518
md
md'
Requested
fd
5516
5515
5517

FIG. 55

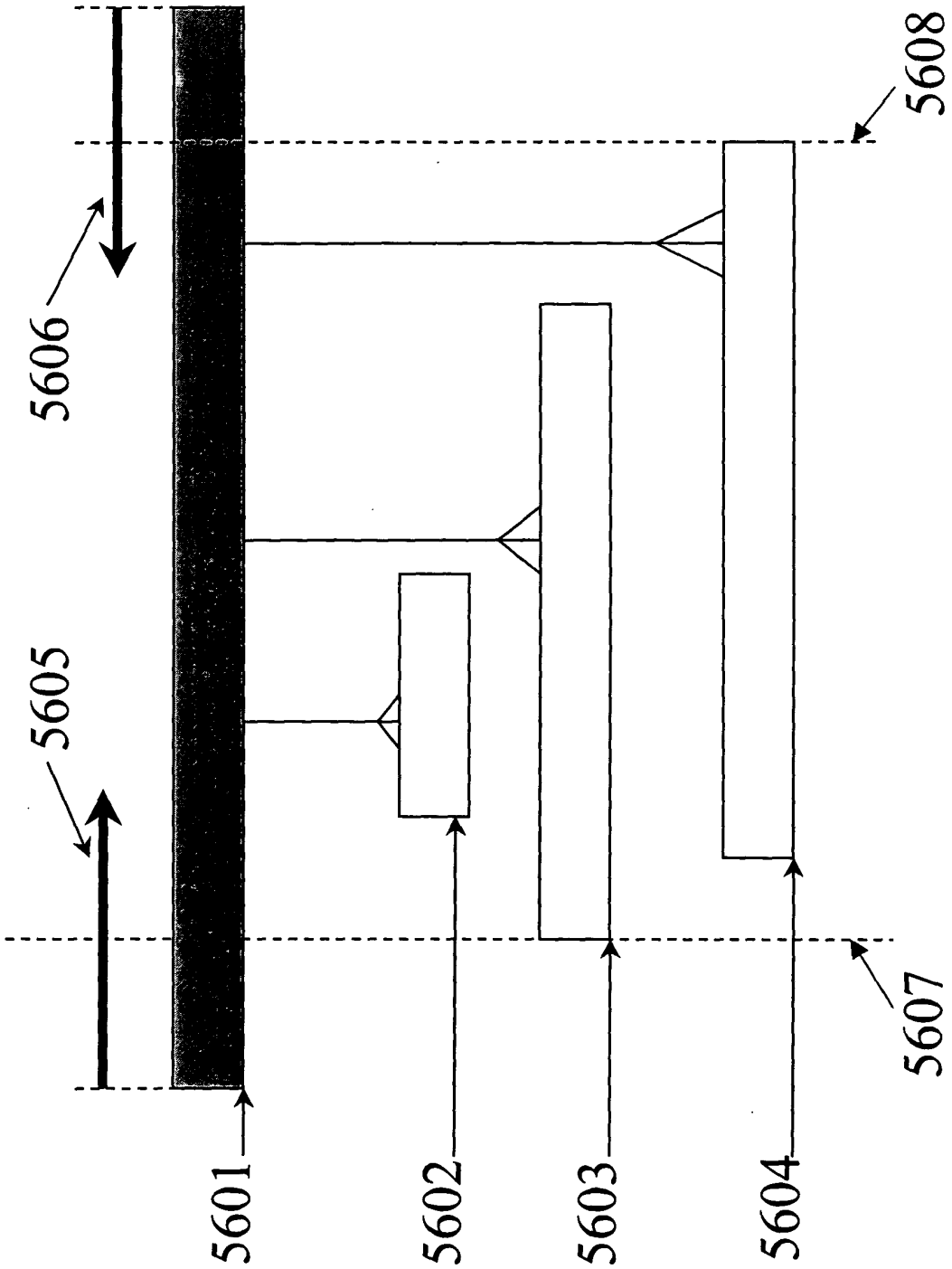


FIG. 56

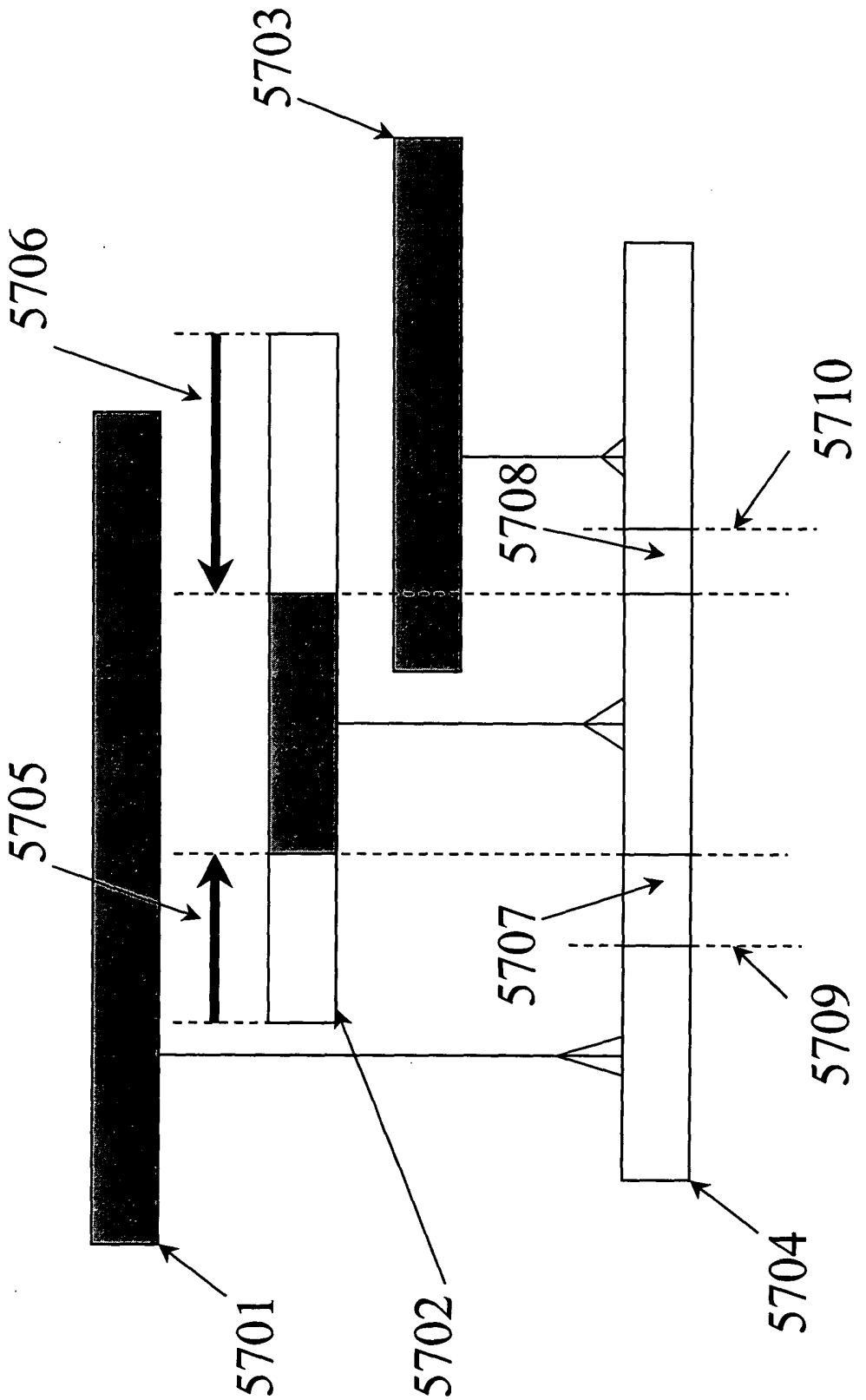


FIG. 57

If Rule on foreign key attribute on focus entity = cascade then
  Actual ui = ui (e.g. Figure 22a).
  Actual fi -> Actual ui (e.g. Figure 22a).
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual ui -> ui' (e.g. Figure 22b) which is not allowed as this would effectively change ui therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual ui -> ui' (e.g. Figure 22c) which is not allowed as this would effectively change ui therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys.
Actual ui = ui (e.g. Figure 22d).
Actual fi = Requested fi.
Focus entity connected to default upstream entity from Requested fi to ui.
Focus entity connected to upstream entity from ui.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys.
Actual ui = ui (e.g. Figure 22e).
Actual fi = Requested fi.
Focus entity connected to null from Requested fi to ui.
Focus entity connected to upstream entity from ui.
end if

FIG. 58a

If Rule on foreign key attribute on focus entity = cascade then
Actual mi = mi.
Actual fi -> Actual mi.
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual mi -> mi' which is not allowed as this would effectively change mi therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual mi -> mi' as which is not allowed as this would effectively change mi therefore the action is not allowed by the system.
Focus entity NOT inserted or alter inserted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys as all master relations are by inspection non transferable then this case is not applicable.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys as all master relations are by inspection non transferable then this case is not applicable.
end if

FIG. 58b

If Rule on foreign key attribute on focus entity = cascade then
Actual ud = ud.
Actual fd -> Actual ud.
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual ud -> ud' which is not allowed as this would effectively change ud therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual ud -> ud' which is not allowed as this would effectively change ud therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys.
Actual ud = ud.
Actual fd = Requested fd.
Focus entity connected to default upstream entity from ud to requested fd.
Focus entity connected to upstream entity upto ud.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys.
Actual ud = ud.
Actual fd = Requested fd.
Focus entity connected to null from ud to Requested fd.
Focus entity connected to upstream entity from upto ud.
end if

FIG. 58c

If Rule on foreign key attribute on focus entity = cascade then
Actual md = md.
Actual fd -> Actual md.
end if

If Rule on foreign key attribute on focus entity = bounded cascade then
Actual md -> md' which is not allowed as this would effectively change md therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = restrict then
Actual md -> md' as which is not allowed as this would effectively change md therefore the action is not allowed by the system.
Focus entity NOT alter deleted.
end if

If Rule on foreign key attribute on focus entity = Defaults then
Only applies to transferable optional and transferable mandatory foreign keys. As all master relations are by inspection non transferable then this case is not applicable.
end if

If Rule on foreign key attribute on focus entity = Nullifies then
Only applies to transferable optional foreign keys. As all master relations are by inspection non transferable then this case is not applicable.
end if

FIG. 58d

Action occurs on a row in a Focus Entity:

Refer to the Temporal Referential Tree to create stack of related entities i.e. all immediate upstream entities and all downstream entities.

Determine Referential Boundary Conditions using related rows in Affected Entities

Determine the order in which to process related rows.

For each row

    Apply referential rules, taking into account the attribute and entity rules of the related entities as defined in the Temporal Data Dictionary

End-For

FIG. 59

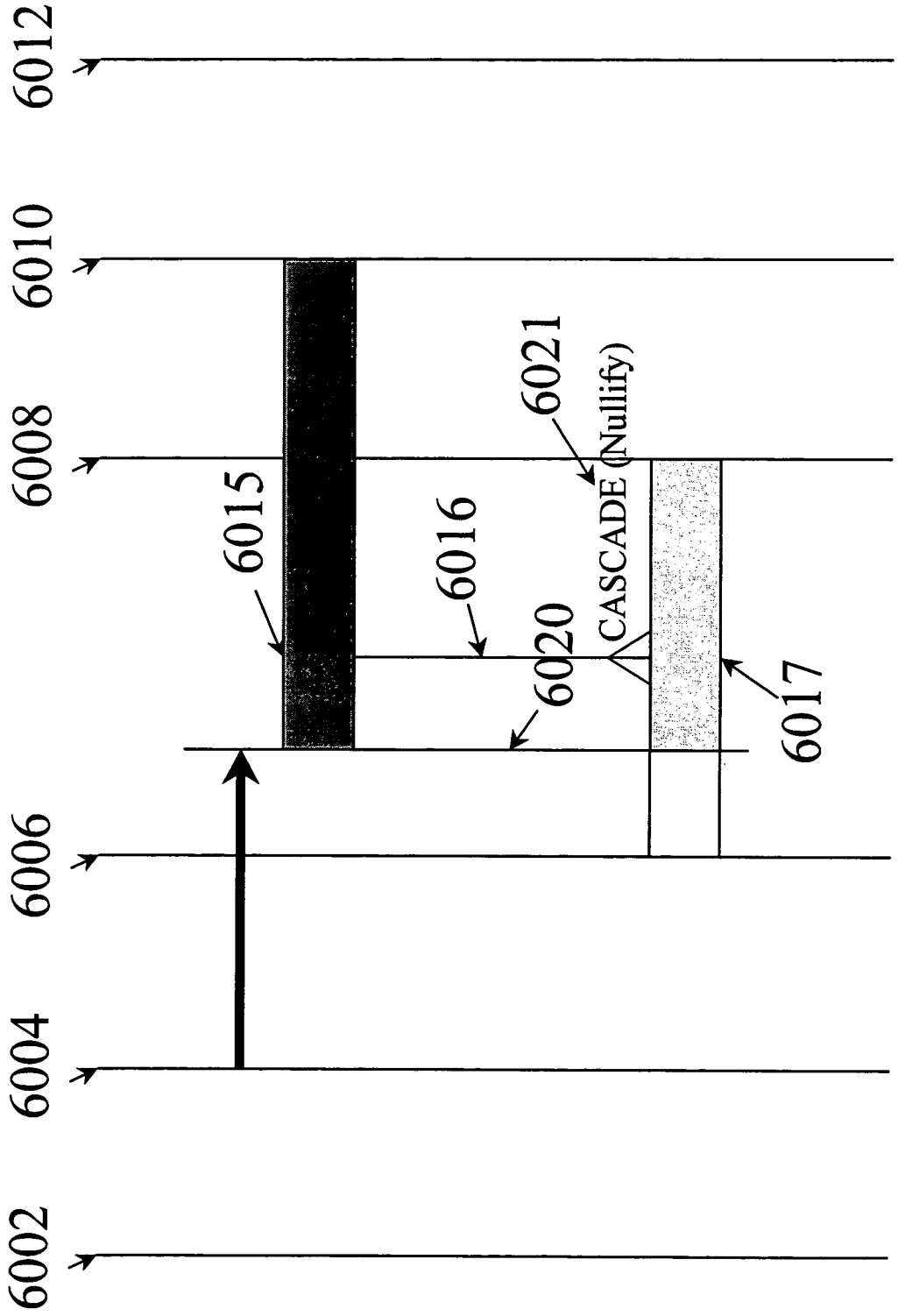

6012
6010
6008
6006
6004
6002
6015
6016
6020
6021
CASCADE (Nullify)
6017

FIG. 60

Abbreviation for Relationship Type	Description of Relationship Type	Example of focus entity	Example of related entity
dlnto	downstream lookup non transferrable optional	product	order line
dlntm	downstream lookup non transferrable mandatory	product	order line
dlto	downstream lookup transferrable optional	department	employee
dltm	downstream lookup transferrable mandatory	department	employee
ulnto	upstream lookup non transferrable optional	order line	product
ulntm	upstream lookup non transferrable mandatory	order line	product
ulto	upstream lookup transferrable optional	employee	department
ultm	upstream lookup transferrable mandatory	employee	department
mst	master (always nontransferrable nt and mandatory m)	order	na
chd	child (always nontransferrable nt and mandatory m)	order line	order

FIG. 61

Abbreviation for Rule Type	Rule Type
e	cascade (with attribution rule of extend)
b	bounded
r	restrict
d	cascade (with attribution rule of default)
n	cascade (with attribution rule of nullify)

FIG. 62

Time Points	Description
xs	start of xtime
fi	focus insert time
fd	focus delete time
di	downstream insert time
dd	downstream delete time
mi	master insert time
md	master delete time
ui	upstream insert time
ud	upstream delete time
ci	child insert time
cd	child delete time
xe	end of xtime

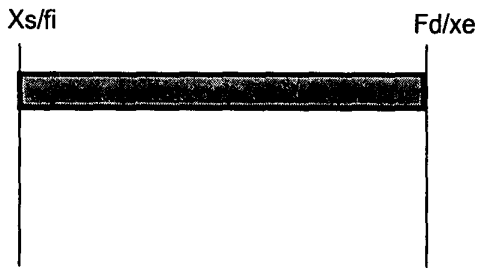
FIG. 63

Action	Description of Action
Insert	entity inserted with a delete time of xe
Alter Insert Back	entity insert time moved to an earlier time
Alter Insert Forward	entity insert time moved to a later time
Update	change to a primary or foreign key value
Delete	entity delete time altered from xe to an earlier time
Alter Delete Back	entity delete time altered to an earlier time
Alter Delete Forward	entity delete time altered to a later time

FIG. 64

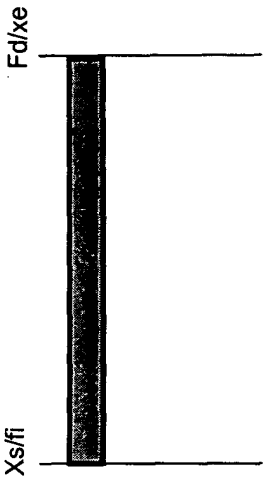
Code	Description of Result
1	Action not allowed / breaks referential rules or entity rules / rollback
2	Action allowed / referential rules activated
3	Action allowed / no referential rules activated
4	Rule does not apply to case e.g. nullifies on master relation

FIG. 65



ACTION			RULE	TYPE							
				dlnto		dlntm		dlto		dltm	
	xs/fi	fd/xe		result	note	result	note	result	note	result	note
insert			e	3		3		3		3	
			b	3		3		3		3	
			r	3		3		3		3	
			d	4		4		4		4	
			n	4		4		4		4	

FIG. 66



	ACTION		RULE	TYPE	chd	result	note
		fd/xe	e			3	
			b			3	
			r			3	
			d			4	
			n			4	
	insert	xs/fi					

FIG. 67

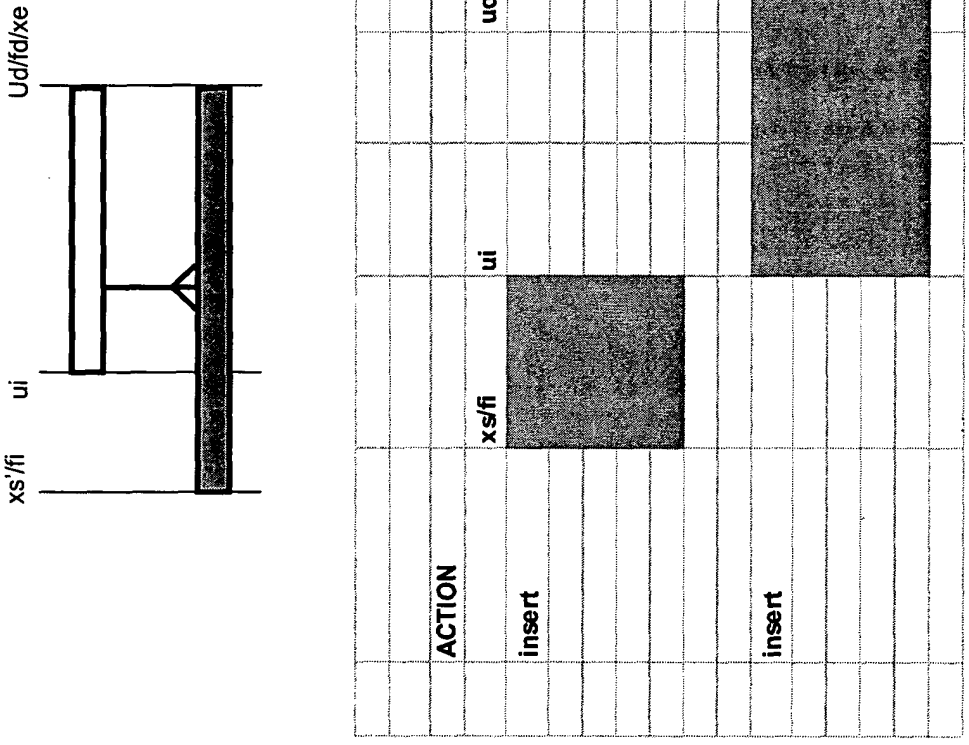
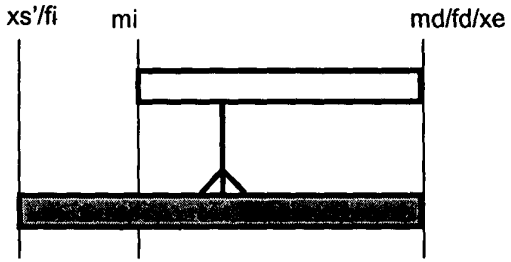

Ud/fd/xe
ui
xs'/fi
RULE
ACTION
xs/fi
ui
ud/fd/xe
insert
insert
e
b
r
d
n

FIG. 68a

RULE	TYPE							
	ulnto		ultnm		ulto		ultm	
	result	note	result	note	result	note	result	note
e	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a
b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b
r	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig22c
d	4		4		2	fi stays, fig50 and fig22d	2	fi stays, fig50 and fig22d
n	4		4		2	fi stays, fig50 and fig22e	4	
e	3	fig51	3	fig51	3	fig51	3	fig51
b	3	fig51	3	fig51	1		1	
r	3	fig51	3	fig51	1		1	
d	4		4		3	fig51	3	fig51
n	4		4		3	fig51	4	

FIG. 68b



								RULE	TYPE		
									mst		
	ACTION								result	note	
			xs/fi	mi		md/fd/xe					
	insert							e	2	fi -> mi, fig50 and fig22a	
								b	1	fig50 and fig22b	
								r	1	fig50 and fig22c	
								d	4		
								n	4		
	insert							e	2	fi -> mi, fig52	
								b	1	fig52	
								r	1	fig52	
								d	4	fig52	
								n	4	fig52	

FIG. 69

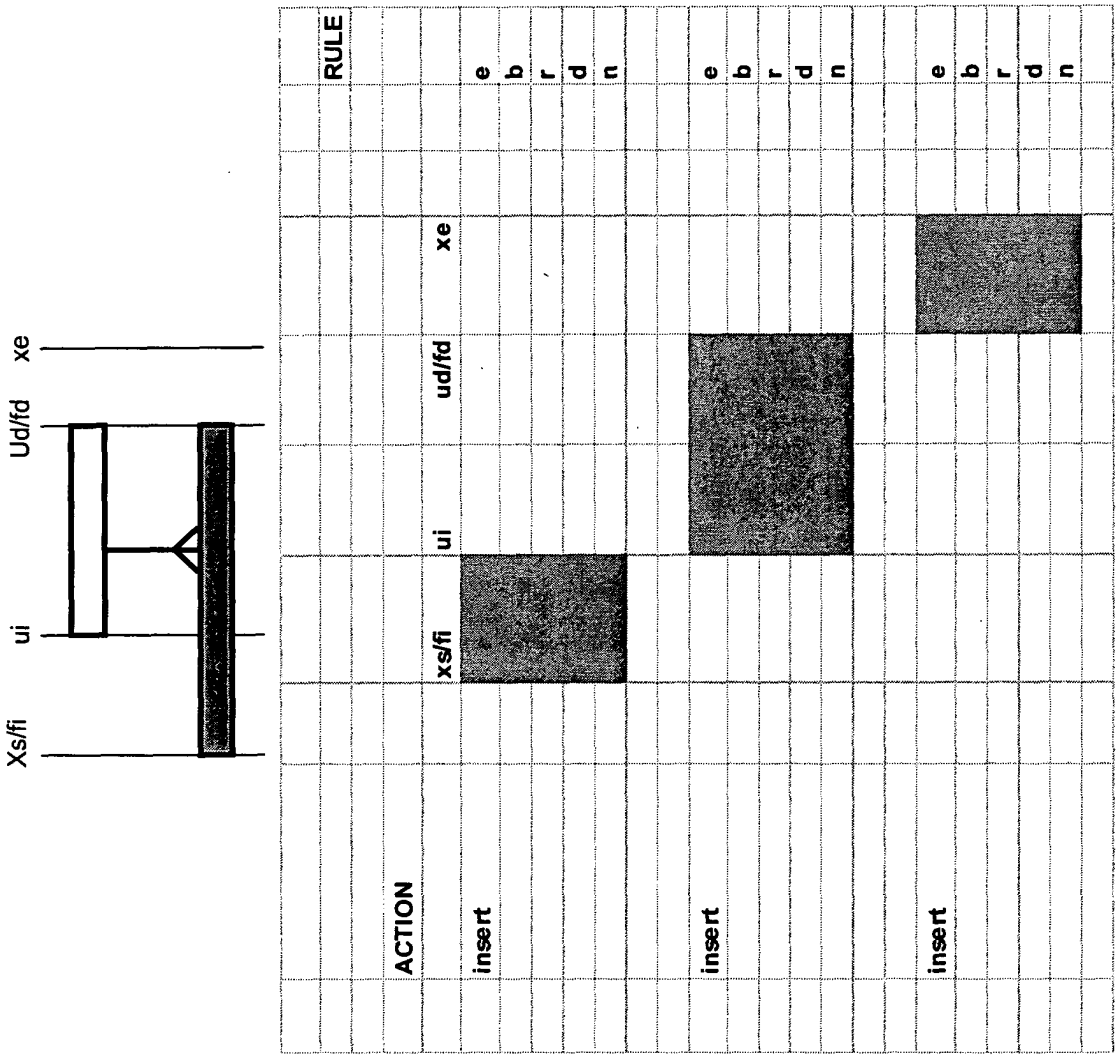

Xs/fi
ui
Ud/fd
xe
RULE
ACTION
xs/fi
ui
ud/fd
xe
e
b
r
d
n
insert
insert
insert

FIG. 70a

RULE	TYPE							
	uInto		uIntm		uIto		uItm	
	result	note	result	note	result	note	result	note
e	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a
b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b
r	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig22c
d	4		4		2	fi stays, fig50 and fig22d	2	fi stays, fig50 and fig22d
n	4		4		2	fi stays, fig50 and fig22e	4	
e	3		3		3		3	
b	3		3		1		1	
r	3		3		1		1	
d	4		4		3		3	
n	4		4		3		4	
	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rul
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1		1	
n	4		4		1		4	

FIG. 70b

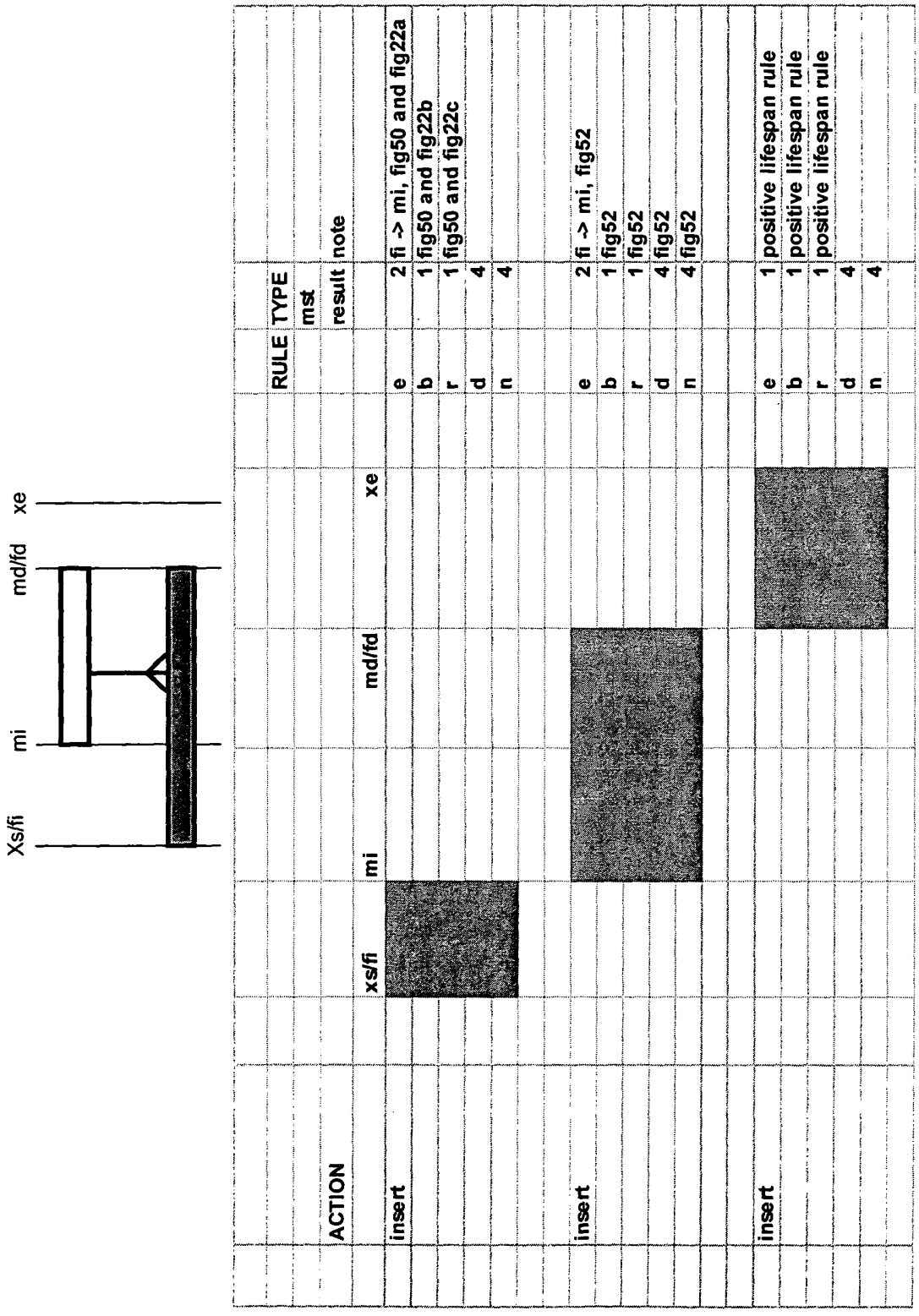

Xs/fi
mi
md/fd
xe
ACTION
xs/fi
mi
md/fd
xe
RULE
TYPE
mst
result
note
insert
e 2 fi -> mi, fig50 and fig22a
b 1 fig50 and fig22b
r 1 fig50 and fig22c
d 4
n 4
insert
e 2 fi -> mi, fig52
b 1 fig52
r 1 fig52
d 4 fig52
n 4 fig52
insert
e 1 positive lifespan rule
b 1 positive lifespan rule
r 1 positive lifespan rule
d 4
n 4

FIG. 71

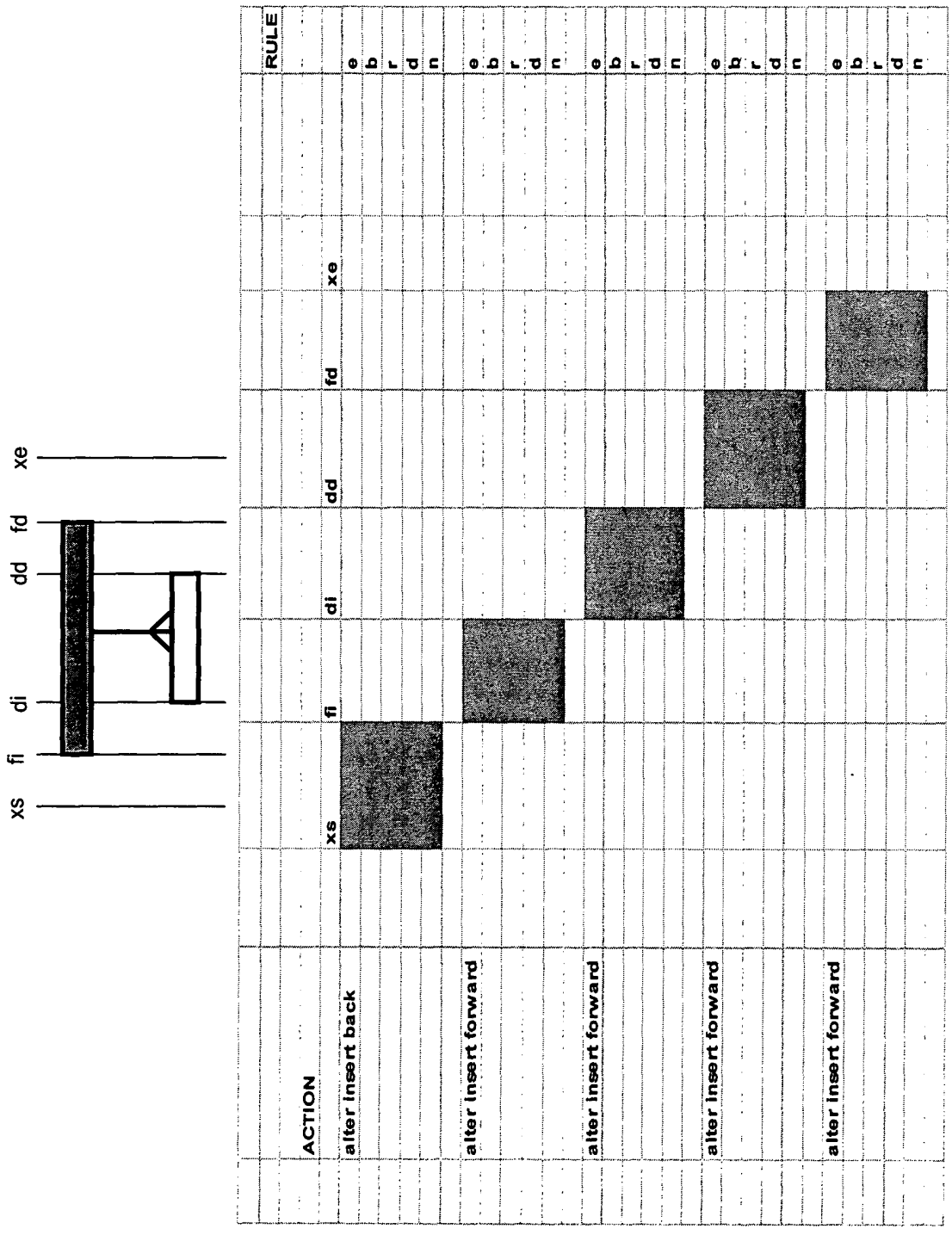
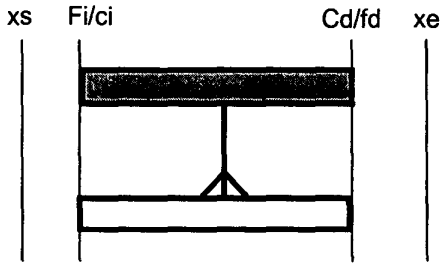

xs
fi
di
dd
fd
xe
RULE
ACTION
xs
fi
di
dd
fd
xe
alter insert back
alter insert forward
alter insert forward
alter insert forward
alter insert forward
e
b
r
d
n

FIG. 72a

RULE	TYPE							
	dInto		dIntm		dIto		dItm	
	result	note	result	note	result	note	result	note
e	3	fig20	3	fig20	3	fig20	3	fig20
b	3	fig20	3	fig20	3	fig20	3	fig20
r	3	fig20	3	fig20	3	fig20	3	fig20
d	4		4		3	fig20	3	fig20
n	4		4		3	fig20	4	
e	3	fig21	3	fig21	3	fig21	3	fig21
b	3	fig21	3	fig21	3	fig21	3	fig21
r	3	fig21	3	fig21	3	fig21	3	fig21
d	4		4		3	fig21	3	fig21
n	4		4		3	fig21	4	
e	2	fig22a	2	fig22a	2	fig22a	2	fig22a
b	2	fi -> di, fig22b	2	fi -> di, fig22b	2	fi -> di, fig22b	2	fi -> di, fig22b
r	2	fig22c	2	fig22c	2	fig22c	2	fig22c
d	4		4		2	fig22d	2	fig22d
n	4		4		2	fig22e	4	
e	2	disconnect or delete, fig23a	2	disconnect or delete, fig23a	2	disconnect or delete, fig23a	2	disconnect or delete, fig23a
b	2	fi -> di, fig23b	2	fi -> di, fig23b	2	fi -> di, fig23b	2	fi -> di, fig23b
r	3	fig23c	2	fig23c	2	fig23c	2	fig23c
d	2	disconnect, fig23d	2	disconnect, fig23d	2	disconnect, fig23d	2	disconnect, fig23d
n	2	disconnect, fig23e	4		2	disconnect, fig23e	4	
e	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
b	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
r	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
d	4		4		1	positive lifespan rule, fig24	1	positive lifespan rule, fig24
n	4		4		1	positive lifespan rule, fig24	4	

FIG. 72b



ACTION	xs	fi/ci	cd/fd	xe	RULE	TYPE chd result	note
alter insert back					e	3	
					b	3	
					r	3	
					d	4	
					n	4	
alter insert forward					e	2	
					b	2	fi -> ci
					r	2	
					d	4	
					n	4	
alter insert forward					e	1	positive lifespan rule
					b	1	positive lifespan rule
					r	1	positive lifespan rule
					d	4	
					n	4	

FIG. 73

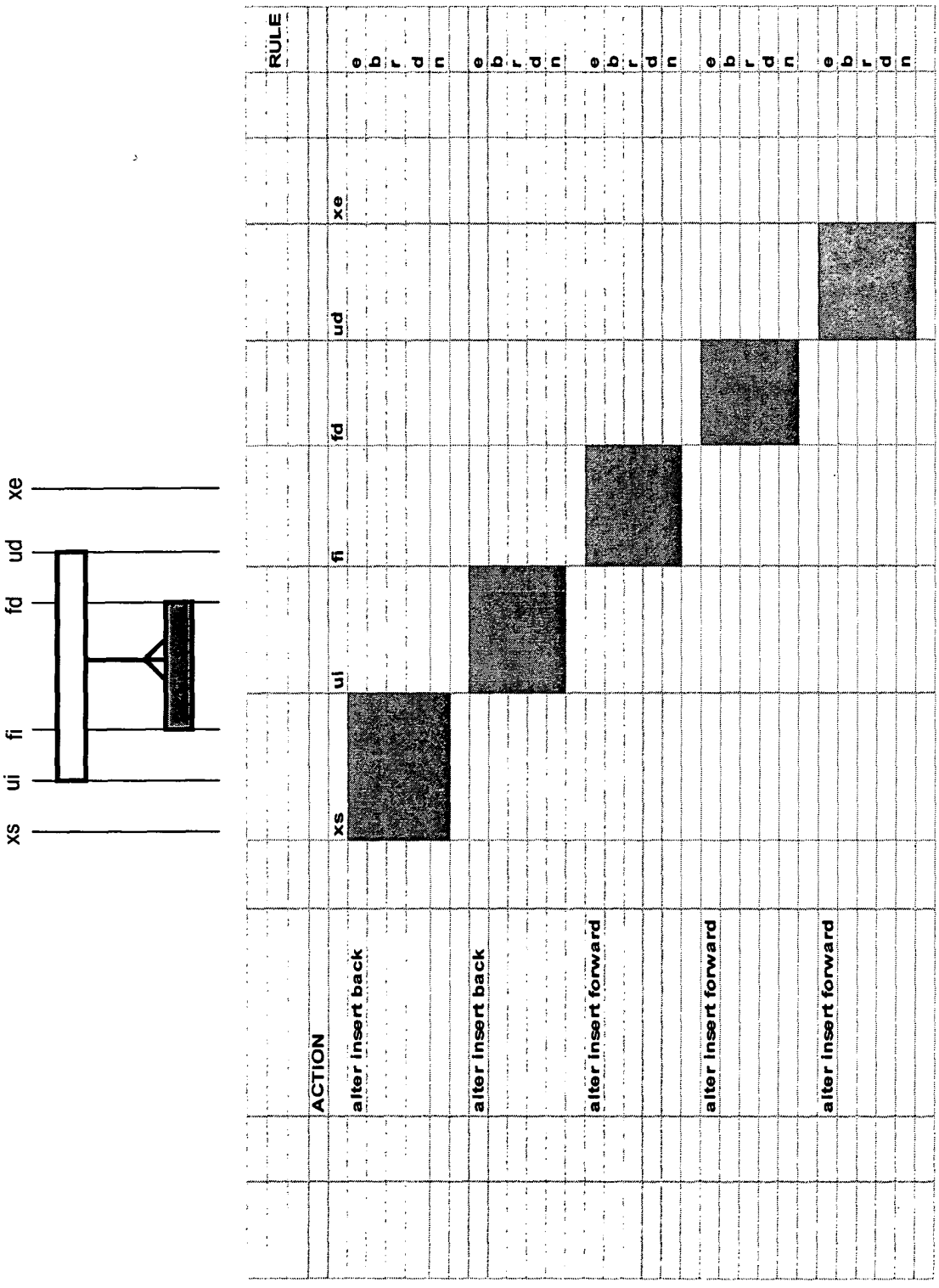
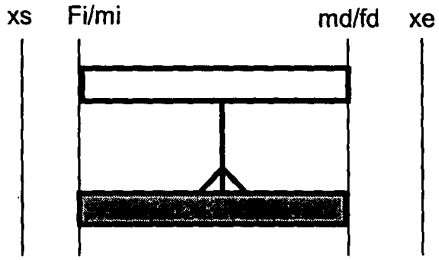

xs
ui
fi
fd
ud
xe
RULE
ACTION
xs
ui
fi
fd
ud
xe
e
b
r
d
n
alter insert back
alter insert forward

FIG. 74a

RULE	TYPE							
	ulnto		ulntm		ulto		ultm	
	result	note	result	note	result	note	result	note
e	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a	2	fi -> ui, fig50 and fig22a
b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b	1	fig50 and fig22b
r	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig 50 and fig22c	1	fig22c
d	4		4		2	fi stays / disconnect, fig50 and fig22d	2	fi stays, fig50 and fig22d
n	4		4		2	fi stays / disconnect, fig50 and fig22e	4	
e	3	fig51	3	fig51	3	fig51	3	fig51
b	3	fig51	3	fig51	3	fig51	3	fig51
r	3	fig51	3	fig51	3	fig51	3	fig51
d	4		4		3	fig51	3	fig51
n	4		4		3	fig51	4	
e	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rule
n	4		4		1	positive lifespan rule	4	
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rule
n	4		4		1	positive lifespan rule	4	

FIG. 74b



							RULE	TYPE	
								mst	
ACTION								result	note
		xs	fi/mi	md/fd	xe				
alter insert back							e	2	fi -> mi, fig50 and fig22a
							b	1	fig50 and fig22b
							r	1	fig50 and fig22c
							d	4	
							n	4	
alter insert forward							e	2	fi -> mi, fig52
							b	1	fig52
							r	1	fig52
							d	4	fig52
							n	4	fig52
alt r insert forward							e	1	positive lifespan rule
							b	1	positive lifespan rule
							r	1	positive lifespan rul
							d	4	
							n	4	

FIG. 75

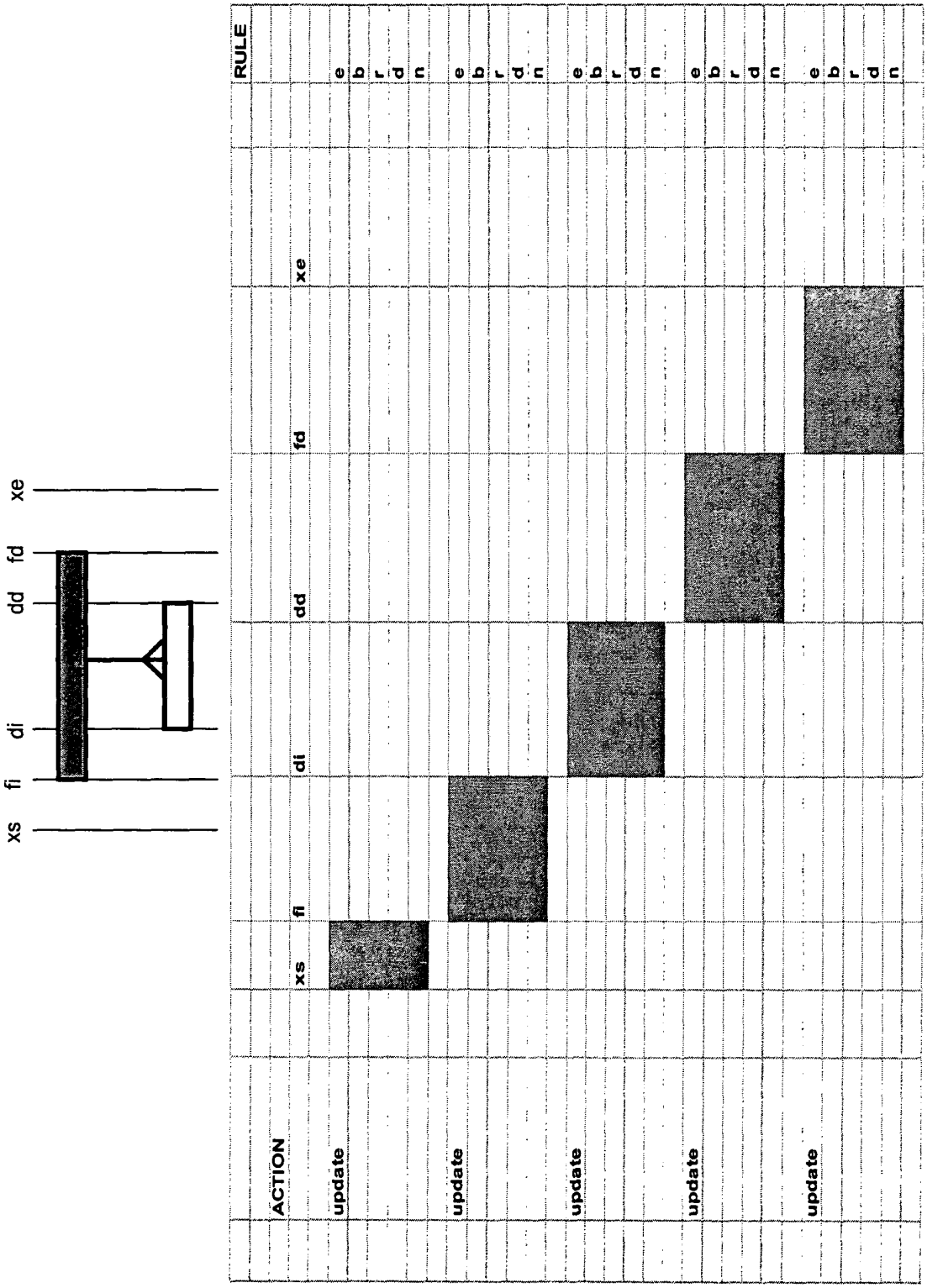


FIG. 76a

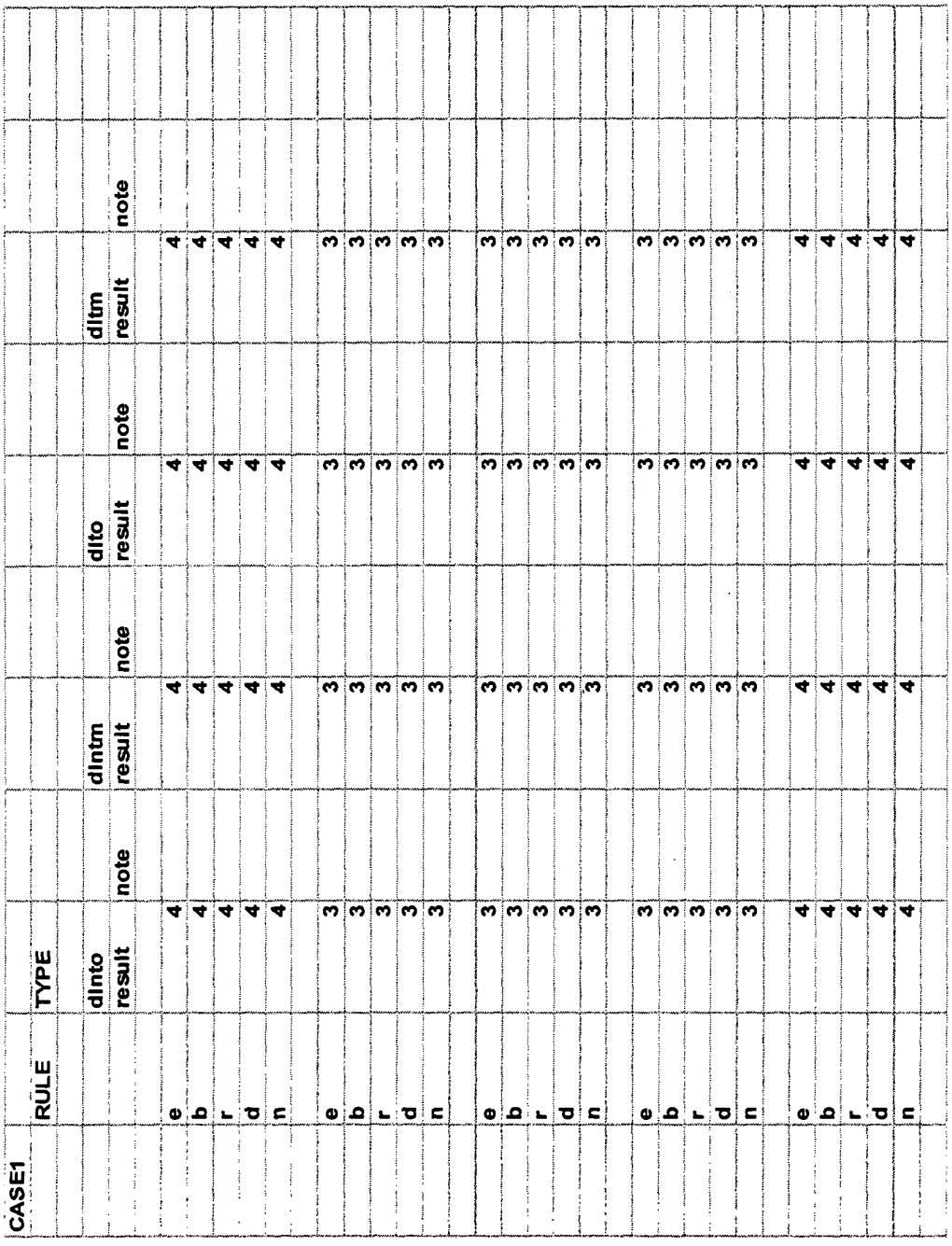

CASE1
RULE
TYPE
dInto result
note
dIntm result
note
dIto result
note
dItm result
note

FIG. 76b

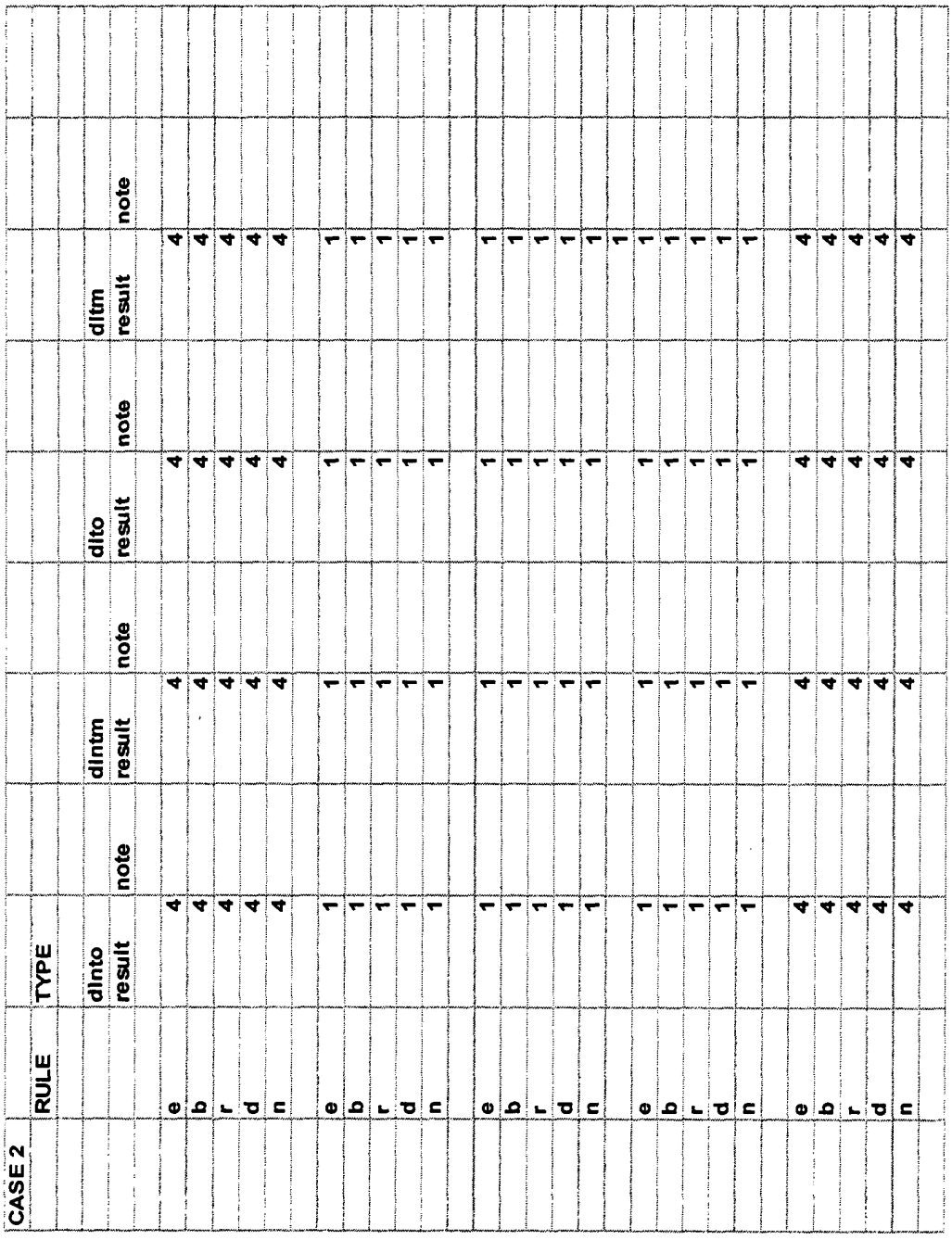

CASE 2
RULE
TYPE
dInto result
note
dIntm result
note
dIto result
note
dItm result
note

FIG. 76c

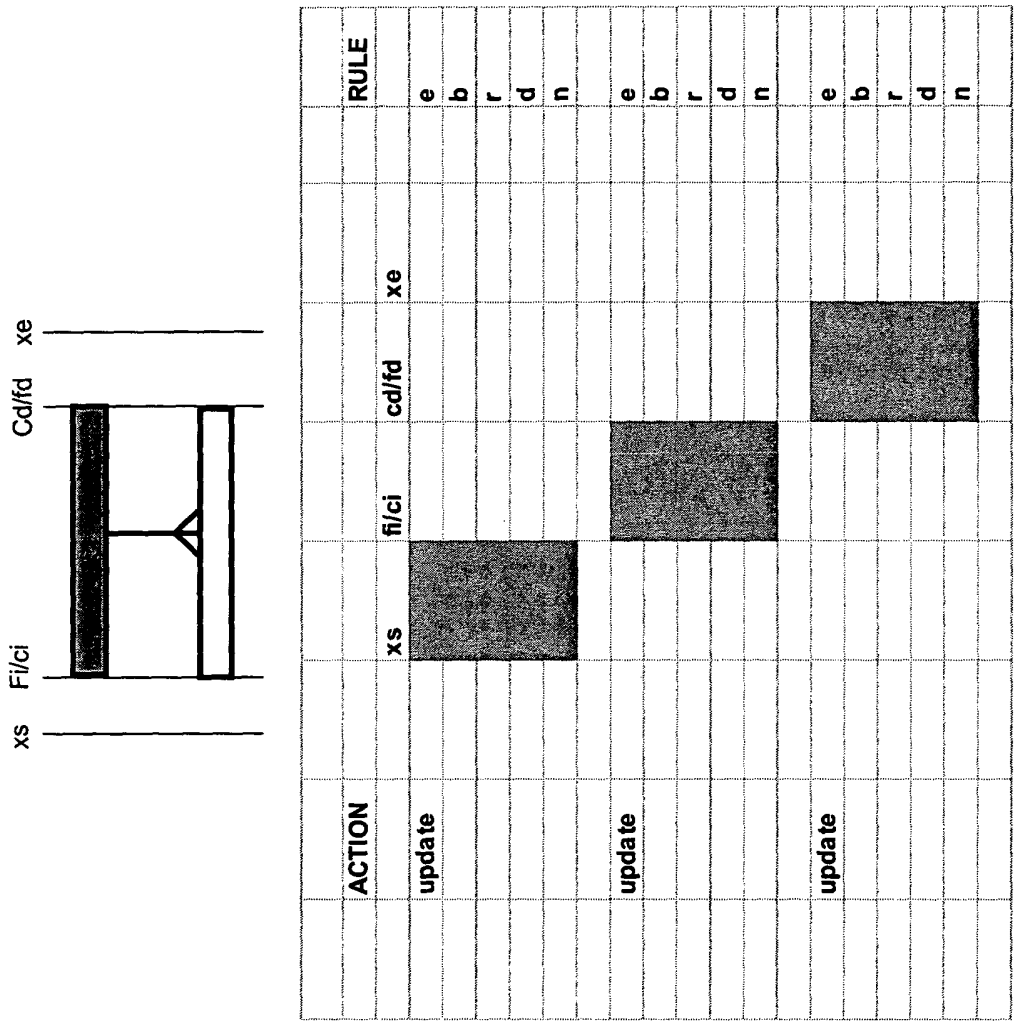

xs
Fi/ci
Cd/fd
xe
ACTION
RULE
xs
fi/ci
cd/fd
xe
update
update
update
e
b
r
d
n

FIG. 77a

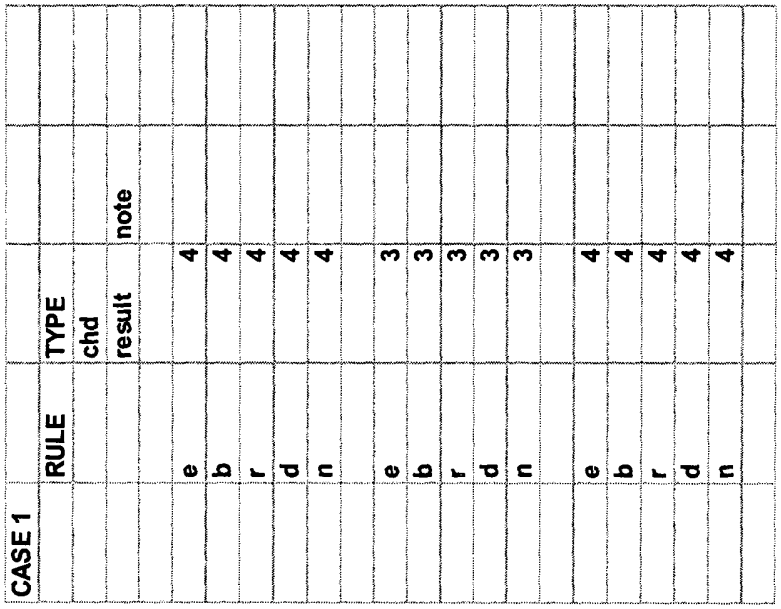

CASE 1
RULE
TYPE
chd
result
note
e 4
b 4
r 4
d 4
n 4
e 3
b 3
r 3
d 3
n 3
e 4
b 4
r 4
d 4
n 4

FIG. 77b

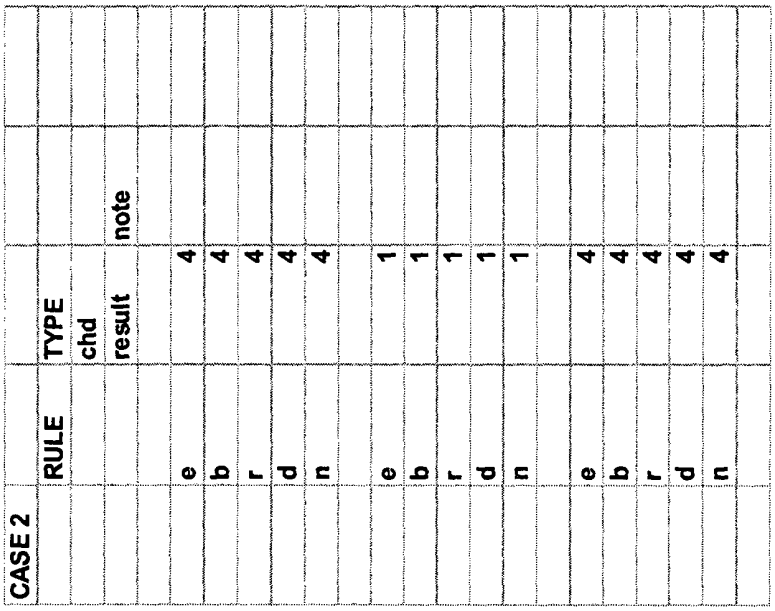

CASE 2
RULE
TYPE
chd
result
note
e 4
b 4
r 4
d 4
n 4
e 1
b 1
r 1
d 1
n 1
e 4
b 4
r 4
d 4
n 4

FIG. 77c

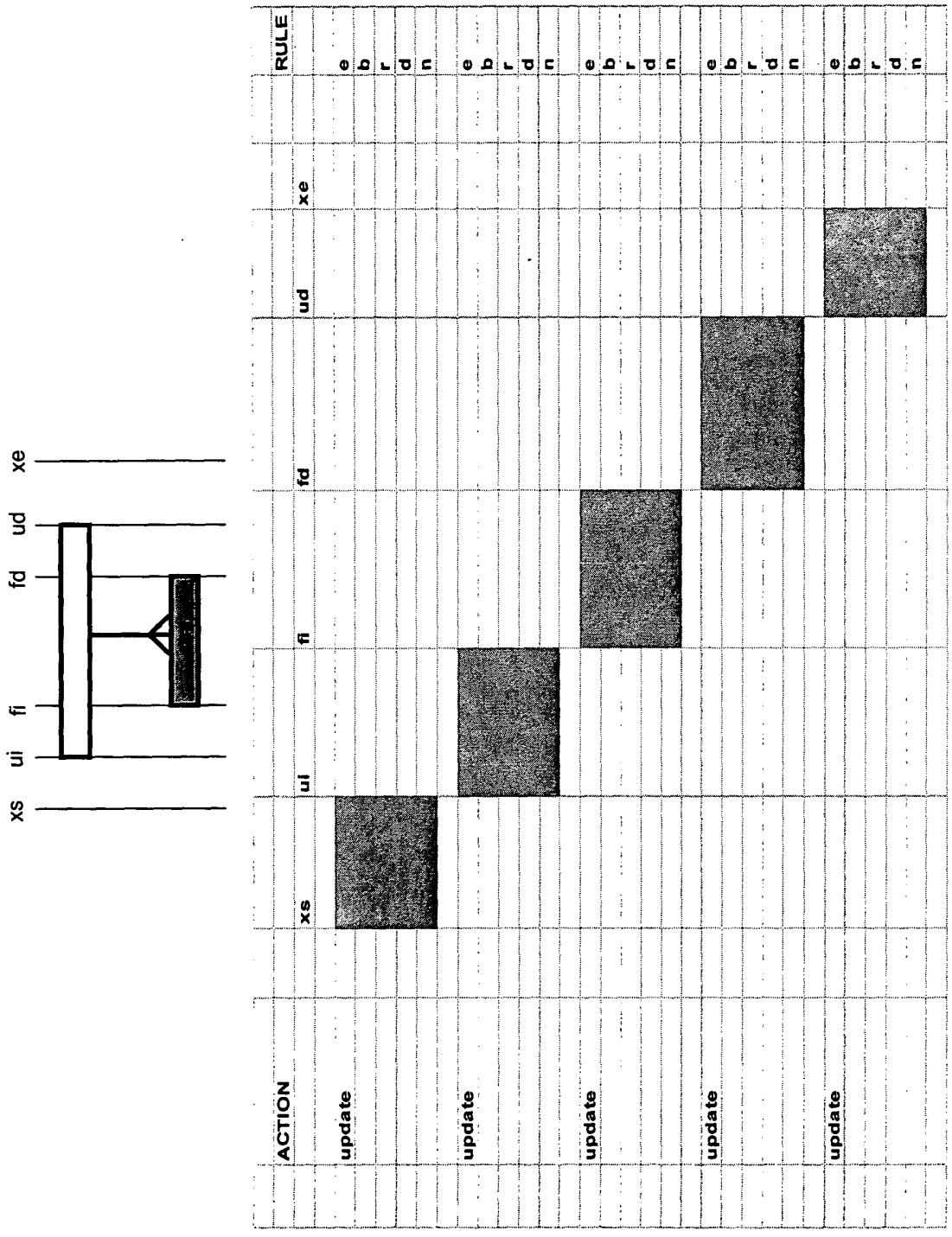


FIG. 78a

	TYPE								
RULE	ulnto		ulntm		ulto		ultm		
	result	note	result	note	result	note	result	note	
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						
e	4		4						
b	4		4						
r	4		4		see fig 70a and 70b		see fig 70a and 70b		
d	4		4		for ulto, ultm		for ulto, ultm		
n	4		4						

FIG. 78b

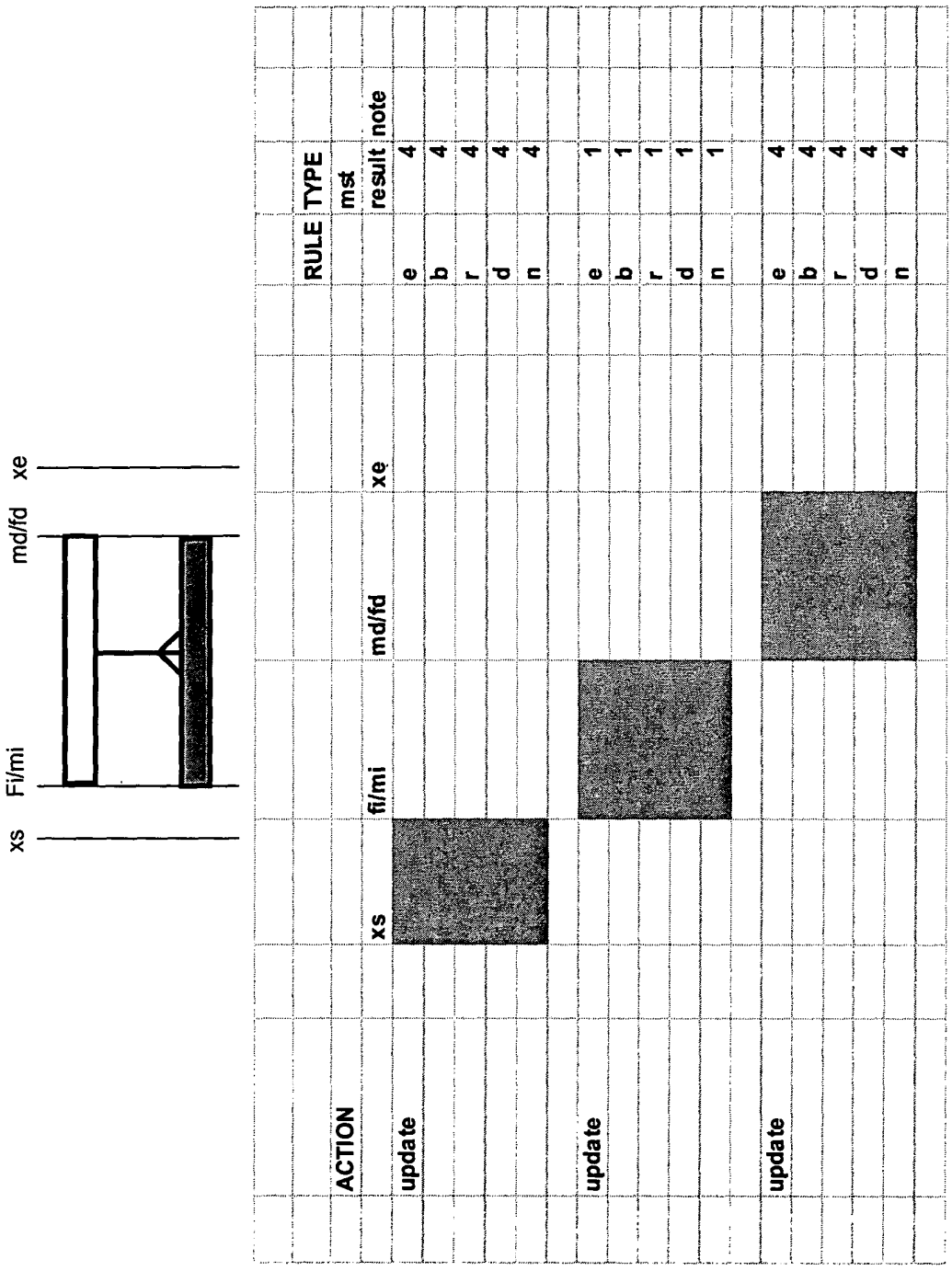
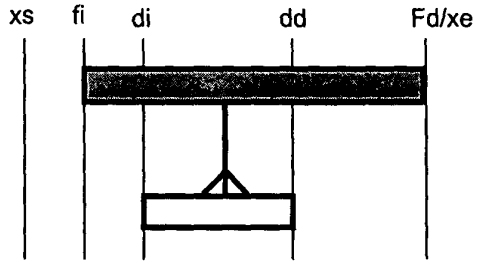
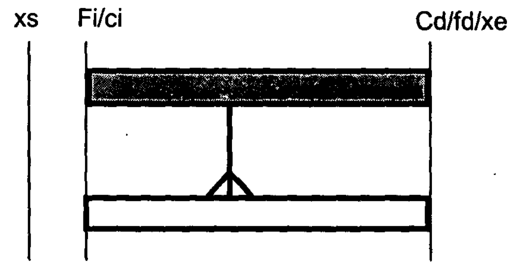

xs
fi/mi
md/fd
xe
ACTION
RULE TYPE
mst
result note
update
update
update

FIG. 79



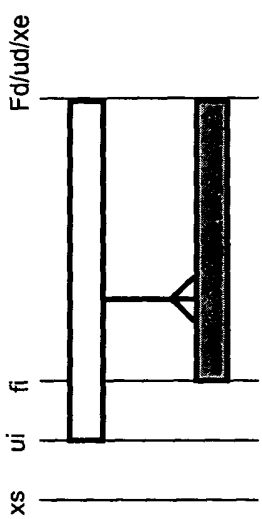
ACTION	xs	fi	di	dd	fd/xe	RULE	Result
d lete						e	
						b	
						r	see fig 84a and 84b for
						d	dInto, dIntm, dIto, dItm
						n	
d lete						e	
						b	
						r	see fig 84a and 84b for
						d	dInto, dIntm, dIto, dItm
						n	
d let						e	
						b	
						r	see fig 84a and 84b for
						d	dInto, dIntm, dIto, dItm
						n	
d let						e	
						b	
						r	see fig 84a and 84b for
						d	dInto, dIntm, dIto, dItm
						n	

FIG. 80



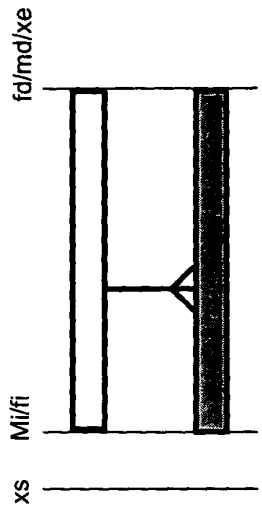
								RULE	Result	
	ACTION									
			xs	fi/ci	cd/fd/xe					
	delete							e		
								b		
								r	see fig 85	
								d	for chd	
								n		
	delete							e		
								b		
								r	see fig 85	
								d	for chd	
								n		

FIG. 81



ACTION	xs	ui	fi	fd/ud/xe	RULE	Result
delete					e	
					b	
					r	see fig 86a and 86b for
					d	ulnto, ulntm, ulto, ultm
					n	
delete					e	
					b	see fig 86a and 86b for
					r	ulnto, ulntm, ulto, ultm
					d	
					n	
delete					e	
					b	see fig 86a and 86b for
					r	ulnto, ulntm, ulto, ultm
					d	
					n	

FIG. 82



ACTION	xs	fi/mi	md/fd/xe	RULE	Result
delete				e	
				b	
				r	see fig 87
				d	for mst
				n	
delete				e	
				b	see fig 87
				r	for mst
				d	
				n	

FIG. 83

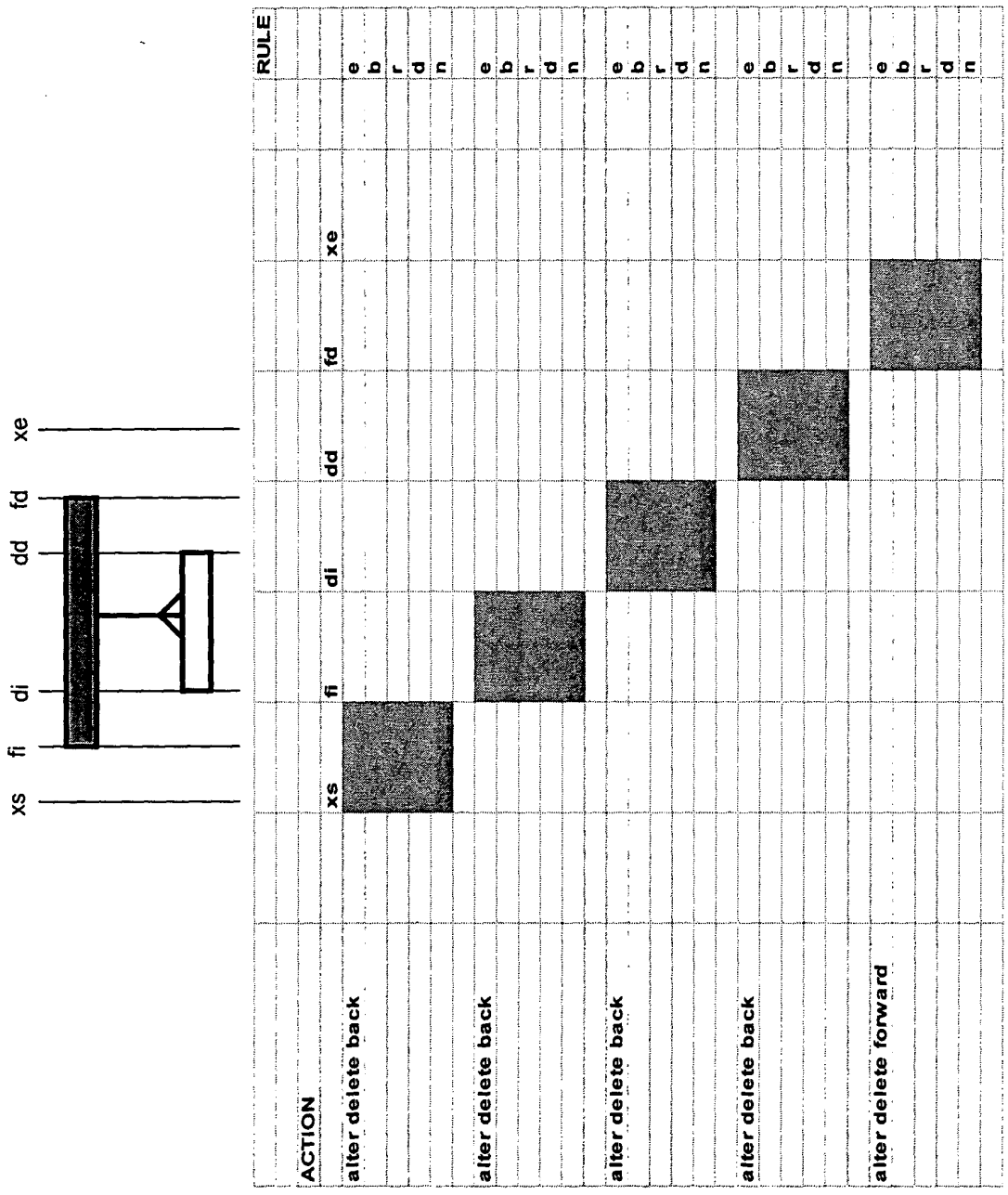
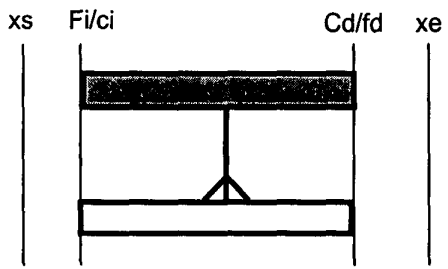

RULE
ACTION
xs
fi
di
dd
fd
xe
alter delete back
alter delete back
alter delete back
alter delete back
alter delete forward
e
b
r
d
n
xs
fi
di
dd
fd
xe

FIG. 84a

RULE	TYPE							
	dInto		dIntm		dIto		dItm	
	result	note	result	note	result	note	result	note
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rul
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rul
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rul
n	4		4		1	positive lifespan rule	4	
	2	disconnect or delete	2	disconnect or delete	2	disconnect or delete	2	disconnect or delete
b	2	fd -> dd	2	fd -> dd	2	fd -> dd	2	fd -> dd
r	3		2		2		2	
d	2	disconnect	2	disconnect	2	disconnect	2	disconnect
n	2	disconnect	4		2	disconnect	4	
	2		2		2		2	
b	2	fd -> dd	2	fd -> dd	2	fd -> dd	2	fd -> dd
r	2		2		2		2	
d	4		4		2		2	
n	4		4		4		4	
e	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	
e	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	

FIG. 84b



								RULE	TYPE		
									chd		
	ACTION								result	note	
			xs	fi/ci	cd/fd	xe					
	alter delete back							e	1	positive lifespan rule	
								b	1	positive lifespan rule	
								r	1	positive lifespan rule	
								d	4		
								n	4		
	alter delete back							e	2		
								b	2	fd ->cd	
								r	2		
								d	4		
								n	4		
	alter delete forward							e	3		
								b	3		
								r	3		
								d	4		
								n	4		

FIG. 85

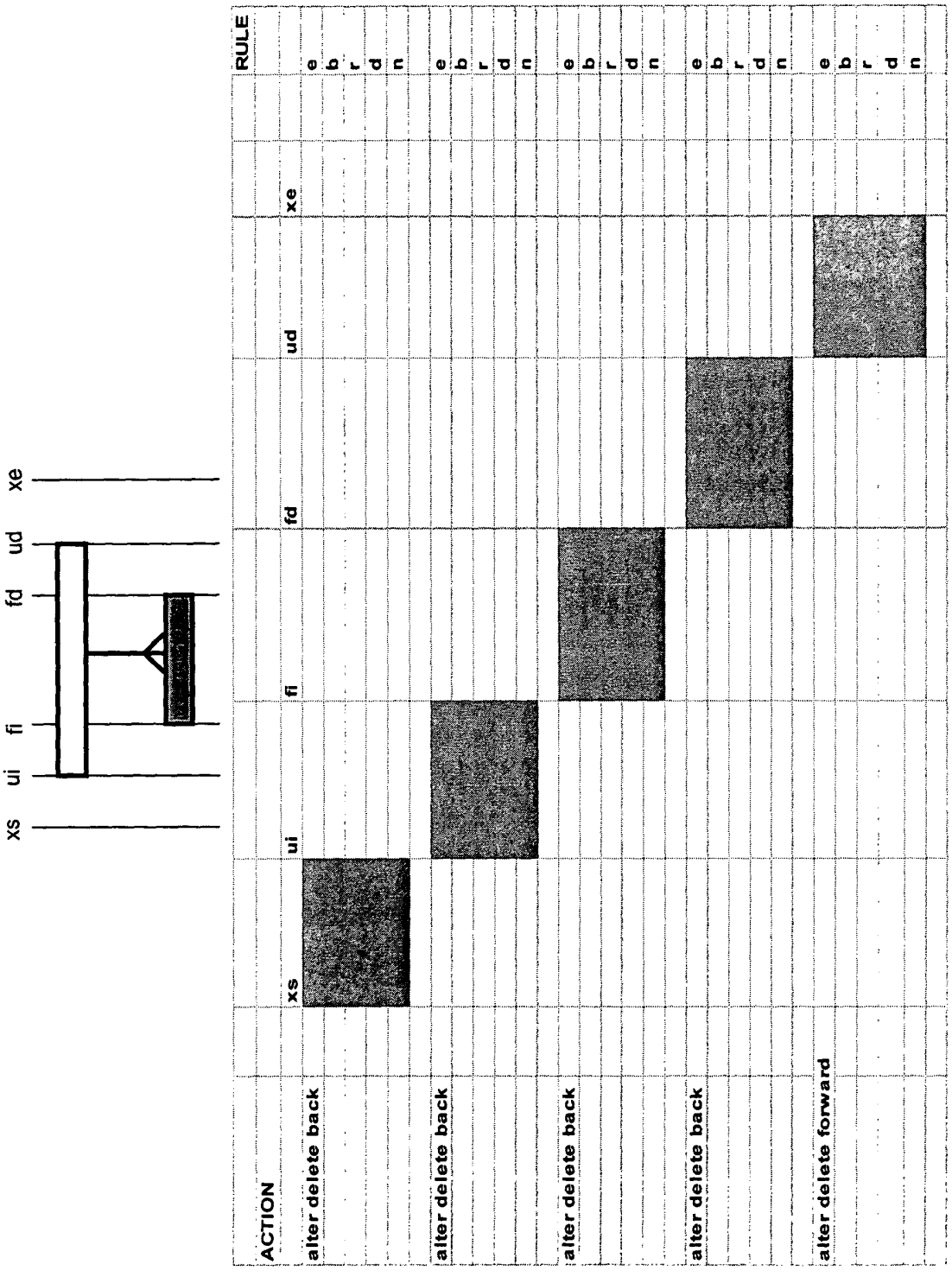
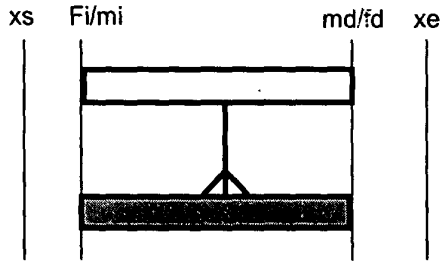

xs
ui
fi
fd
ud
xe
ACTION
RULE
alter delete back
alter delete back
alter delete back
alter delete back
alter delete forward
e
b
r
d
n

FIG. 86a

RULE	TYPE							
	ulnto		ulntm		ulto		ultm	
	result	note	result	note	result	note	result	note
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rule
n	4		4		1	positive lifespan rule	4	
e	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
b	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
r	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule	1	positive lifespan rule
d	4		4		1	positive lifespan rule	1	positive lifespan rule
n	4		4		1	positive lifespan rule	4	
	3		3		3		3	
b	3		3		3		3	
r	3		3		3		3	
d	4		4		3		3	
n	4		4		3		4	
e	3	fig 54	3	fig 54	3	fig 54	3	fig 54
b	3	fig 54	3	fig 54	3	fig 54	3	fig 54
r	3	fig 54	3	fig 54	3	fig 54	3	fig 54
d	4		4		3	fig 54	3	fig 54
n	4		4		3	fig 54	4	
e	2	fd -> ud, fig 53	2	fd -> ud, fig 53	2	fd -> ud, fig 53	2	fd -> ud, fig 53
b	1	fig53	1	fig53	1	fig53	1	fig53
r	1	fig53	1	fig53	1	fig53	1	
d	4		4		2	fd stays / disconnect, fig53	2	fd stays / disconnect, fig53
n	4		4		2	fd stays / disconnect, fig53	4	

FIG. 86b



							RULE	TYPE	
ACTION								mst	
								result	note
		xs	fi/mi	md/fd	xe				
alter delete back							e	1	positive lifespan rule
							b	1	positive lifespan rule
							r	1	positive lifespan rule
							d	4	
							n	4	
alter delete back							e	1	fig55
							b	1	fig55
							r	1	fig55
							d	4	fig55
							n	4	fig55
alter delete forward							e	2	fd -> md, fig53
							b	1	fig53
							r	1	fig53
							d	4	
							n	4	

FIG. 87